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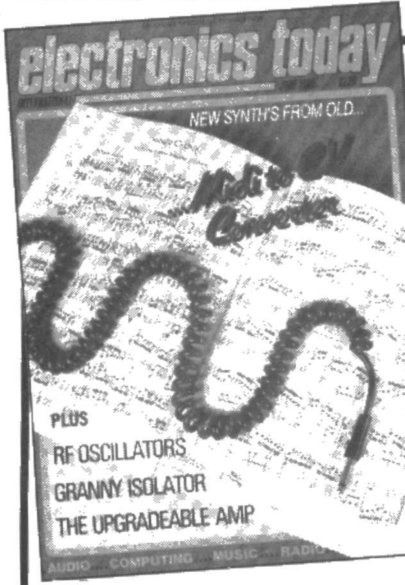

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DIGEST

Dog Eats Dog

Less than a month after the computer supplement of one national newspaper predicted that Sinclair Research was to unveil a direct competitor to the Amstrad PCW8256, Amstrad relieved Sinclair of its responsibilities by buying the company's home computer assets.

The announcement of the £5m deal was made at a press conference on 7 April, jointly hosted by Sir Clive Sinclair, the founder and chairman of Sinclair Research Ltd., and Alan Sugar, founder and chairman of Amstrad Consumer Electronics PLC.

The surprise move came as the conclusion of months of speculation as to the future of Sinclair Research. Although separated from the collapsed Sinclair Vehicles, Sinclair Research is 80% owned by Sir Clive Sinclair whose personal fortune was severely eroded by the failure of the C5 electric vehicle.

Sinclair Research had also massively over-produced for the crisis Christmas of 1984. The seasonal nature of the home computer trade meant that Sinclair could not hope to recover until over a year later but the decline in sales already indicated a loss of between £15 and £16m during 1985.

Towards the end of last year, Sinclair announced a rescue package involving a commitment by high-street retailers, Dixon's, to take £10m worth of Sinclair products. It seems to have been too little, too late.

The Spectrum 128 was not launched early enough to grab the Christmas market and the rest of the Sinclair range failed to sell in large enough volumes despite massive discounting. In effect, many Sinclair products were being sold at cost price.

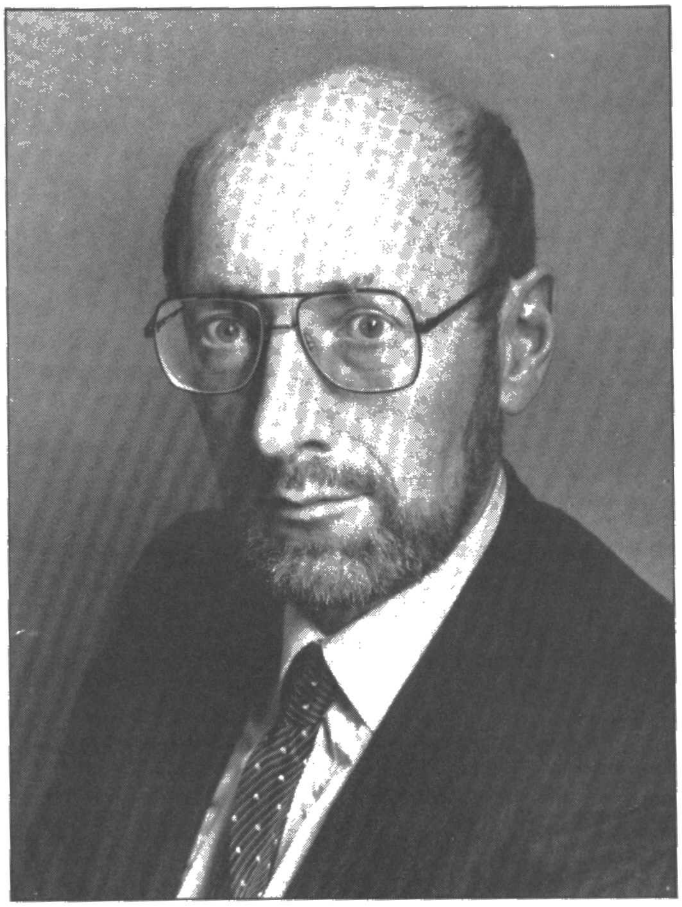
Details of the Amstrad–Sinclair deal are murky, beyond the fact that Amstrad has bought Sinclair's stock, goodwill and rights to manufacture and use the Sinclair trade name. Sinclair claims that it had fulfilled the terms of the 1985 rescue package and paid off its debts by the deadline of 1 April. However, it has been alleged that Sinclair Research was still in debt to the tune of £20m and that major creditors refused to give the company any more leeway. It has also been suggested that the takeover was initiated with the active involvement of Dixon's.

The deal adds a further 40% by volume of the British home computer market to Amstrad's 20% and leaves Sugar's company in a strong position in every sector of the British computer market up to and including small businesses. With profits of £27.5m for the first six months of its financial year to December 1986, Amstrad is almost certainly the UK's leading consumer electronics company, although year-end results will probably show a lower total.

Alan Sugar says that his company will support Sinclair products for a minimum of five years. The QL — which has not been in production for a year — is now formally dropped and rumour has it that Amstrad's bottom-end computers will now be badged 'Sinclair'. It is also widely believed that the Amstrad name will go further up-market with the launch of an IBM PC compatible from the company later this year.

Sinclair Research is now reduced to a holding company overseeing three areas of involvement in high technology: a telecommunications products company in Winchester, the MetaLab research organisation and the wafer-scale integration project which Sinclair and Ivor Catt hope will produce a commercially viable single chip occupying the complete area of a silicon wafer.

●Crisis continues in the UK computer market with Olivetti's recent announcement that is has failed to convince the European market to buy Acorn's BBC range of computers. The former white-hope of the industry — Apricot Computers — have announced that the US trading company, Apricot Inc., in which it holds a 19.9% stake has returned a £14m trading loss for 1985 — its first year of operation. The company is selling its stake to the US managers of Apricot Inc. Apricot had intended to go into profit by the beginning of this year, while it has actually continued to make a loss.



The Colour Blue

At the recent Comdex show in Los Angeles, the world's leading computer company, IBM, launched a laptop PC with integral twin 3½-inch disc drives. The company also announced a new model PC AT and three new PC XTs all with optional 3½-inch drives.

The 3½-inch format represents a major departure for IBM whose enormous resources and influence have, until now, been put behind 5¼-inch floppies. All major software houses in the US have agreed to produce 3½-inch versions of their product.

It seems inevitable that the 5¼ inch disc, like the 8 inch before it, is now on its way out. The weight of IBM's decision is bound to be felt even by home computer users in time.

Bytes Per Cent

The launch of Atari's new desktop personal computer, the 1040ST, may represent a breakthrough as big as those made with the first Apple, the ZX80 or the Commodore 64.

The 1040ST comes complete with 1Mbyte of on-board DRAM for a mere $999. Like the 520ST, the machine uses a 68000 CPU. Atari seem to have ironed-out most of the problems associated with the 520ST and the new machine is more than a match for Commodore's much vaunted Amiga. The $999 price tag includes a monochrome monitor and integral 3½-inch double-sided disc drive. At less than one dollar per kilobyte, the 1040ST is five times better value than the Amiga, around 20 times better value than the Mac and PC AT and an astonishing 150 times better value than the original TRS-80 of less than ten years ago.

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ETI PCB Service

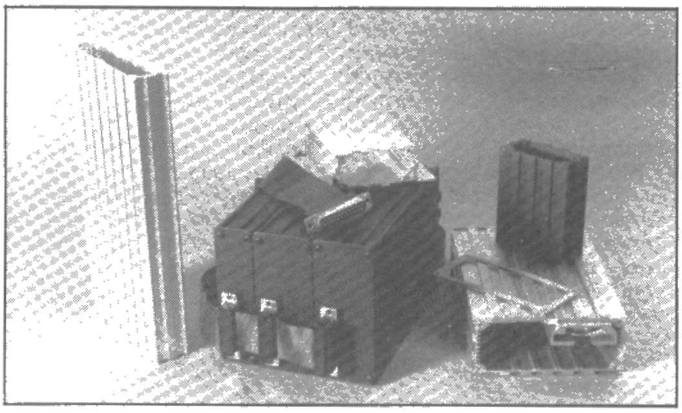
Last month we held-over the PCB Service page, expressing the hope that this did not represent the start of a new round of problems with our suppliers.

Our hope was not fulfilled. After just a few months our new suppliers are already finding it difficult to cope with the running of the service. We are happy to say that they have cleared almost all of the backlog which had built up, but they have now terminated the contract and will not be supplying any further boards. For this reason we have not printed the PCB Service page again this month.

The Service offers a large number of different boards, some of them in very small quantities, and this is not necessarily the most attractive of propositions to a commercial management. Bearing in mind this and the problems we had last time, we cannot offer any guide as to how long it will be before we are able to offer boards again. We will obviously do our best to find a new supplier as quickly as possible.

In the meantime, we can only suggest that our readers treat this as an opportunity to discover (or rediscover) the joys of PCB production. For those unfamiliar with the process, a brief description appears in the article 80m Direct Conversion Receiver in this month's ETI. We will also do our best to find alternative sources for individual boards (authors, kit suppliers, etc.) but this is unlikely to affect more than a small percentage of our projects.

We offer our sincere apologies to readers for this new round of problems.



Versatile Heatsink Cases

Lincoln Binns have introduced a range of extruded aluminium cases which feature integral heatsinking, optional protection against moisture ingress and a system which allows power semiconductors to be mounted in thermal contact with the case walls without the need for drilling. Other items such as feet, mounting brackets, PCB's, etc can also be attached without drilling and the cases can be slotted together in various combinations to form larger units.

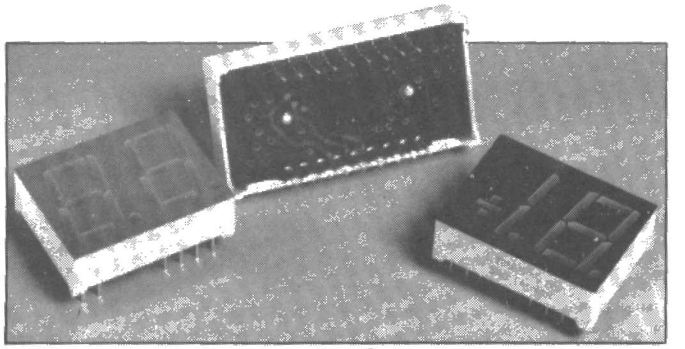
The external walls of the cases have dove-tailed grooves which provide the means whereby cases may be slotted together. The dove-tails also serve as the fins of a heatsink. Various runners slide into these grooves to carry rubber feet, mounting brackets, etc.

Internally, the cases have a series of slots for PCB mounting and a further set of dove-tailed grooves on one face. These can be used with a slide-in carrier which holds power semiconductors. In this way, the semiconductors remain in close thermal contact with the case when in position but can be removed easily along with the PCB for servicing. The slide-in carrier also provides a certain amount of heatsinking on its own, allowing equipment to be tested for short periods outside of the case without the need to extend leads or rig up a temporary heatsink.

A range of end-plates complete the cases, along with sealing gaskets which provide moisture protection. The end-plates overlap the external grooves on two sides to retain fittings and to provide support where several cases are slotted together.

The cases are available in nine sizes from 32 x 63 x 40mm up to 47 x 108 x 220mm in either a natural or black anodised finish and are supplied with matching end-plates. Prices range from £1.35 to £8.80 exclusive of VAT and postage. All accessories are supplied as extras.

Lincoln Binns Ltd, PO Box 110, Haywards Heath, West Sussex, RH17 5YU, tel 0444-451 418.



LED Displays With Integral Drivers

A new range of seven-segment LED displays from Selectronic feature built-in serial-input driver ICs. They come in the same size of package as existing displays and therefore offer a net saving in board space compared with using separate components.

The displays are manufactured by Taiwan Liton and come in a range of five types. The LTM8529x, LTM8530x and LTM8522x displays have 1½, 2 and 3 digits respectively, a character height of 0.56" (14.2mm) and come in red, bright red, high-efficiency red, green, and orange. The LTM8328P and LTM8328KP are four-digit displays with 0.3" high characters and are available only in bright red. The final member of the new range is the LTM8494 which has two 14-segment 'starburst digits' which are 0.54" high.

The integral IC is an M5450 which contains a 35-bit register, 35 LED driver output and a brightness control. Data input to the displays requires two signals, a clock signal and the serial data. Each digit is individually addressable and will continue to display the last character stored until new data is received. The maximum voltage is 15V.

Selectronic Ltd, The Old Stables, 246 Market Square, Witney, Oxfordshire OX8 6AL, tel 0993 – 73888.

Digitally Assisted Television

Research engineers at the BBC have proposed a system whereby high data rate digital signals would be transmitted with the analogue television picture signal to provide supplementary information and control.

Among the possible uses for such signals is to indicate which parts of a television picture contain movement and which don't. By updating only those parts which are moving, the bandwidth required would be reduced.

Early experimental results indicate that HDTV (high definition television) picture quality can be achieved using this system even when the bandwidth has been reduced by a factor of between two and four.

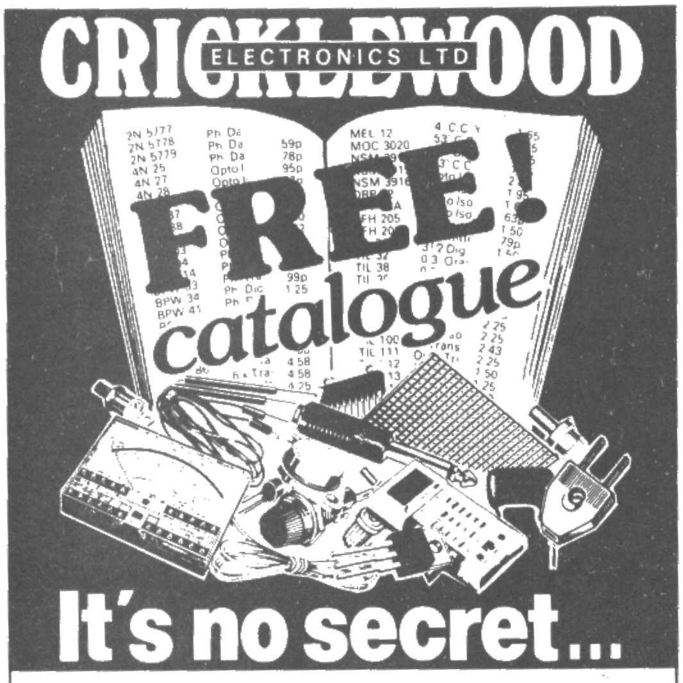
Another possible use for DATV (digitally assisted television) is to carry information which would allow sequentially scanned pictures to be transmitted with interlaced scanning (again, to save the bandwidth) and then reconstructed.

The BBC describe DATV as "... a powerful technique to squeeze HDTV signals through the bottleneck of transmission channels using the sort of technology which will be in our homes in the 1990s". They say they are confident that it will play an important role in establishing a European Broadcasting strategy for high definition television.

BBC Engineering Information Department, Broadcasting House, London W1A 1AA, tel 01-927 5432.

- **When Richard Branson's *Virgin Atlantic Challenger II* attempts to break the world record for crossing the Atlantic, it will be packed full of equipment supplied by Racal Electronics. As well as providing radar and communications systems, Racal plan to use the vessel as a test-bed for their new integrated navigation system.**

- The new Rapid Electronics catalogue runs to 96 A4 pages and lists over 3,500 items. They offer same-day despatch on all orders. The catalogue costs £1.00 including postage (free to schools, private companies, etc.). Rapid Electronics Ltd, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD, tel 0206 – 36730.



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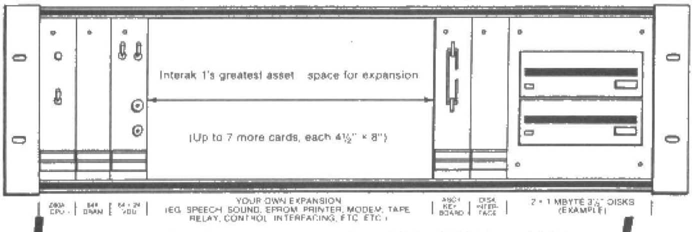
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Charging On

Two recent reports on the state of the international battery market predict rapid and major changes in the next few years.

In particular, both suggest that we will soon see batteries which are built into a product and never need changing or re-charging during the working life of that product.

The two reports come independently from major market research organisations. They point out that there have been more developments in the last decade than in the previous four decades and that we are already beginning to see 'lifetime' batteries in some products such as calculators and watches. With a new generation of lithium batteries, soon to appear, this practice could extend to devices such as radios, VCRs and computers.

The new lithium primary batteries will not only carry more energy than existing types, they will also have a much longer shelf life. This is an important consideration if the battery is to be an integral part of a product which may be stored and unused for long periods.

Developments in the field of rechargeable batteries have moved just as quickly. Existing nickel-cadmium types will be superseded by a new generation of rechargeable cells based on lithium-molybdenum disulphide technology. These have around twice the energy density of nickel-cadmium types and a shelf life nearly ten times as long. They are expected to become commercially available within the next year.

The car battery market will not be left behind. Already small sealed units are beginning to replace the traditional lead-acid type with its poor cold weather performance and frequent need for topping up. The changes which take place in the next few years are expected to go far beyond this.

The Report "Business Opportunities for Batteries and Battery Materials" was produced by SRI International, Menlo Park, California, tel 415 - 859 4276. The other report is entitled "Battery Technologies And Emerging Markets" and is published by International Resource Development Incorporated, 6 Prowitt Street, Norwalk, Conneticutt USA, tel 203 - 866 7800.

Video Cassette Lock

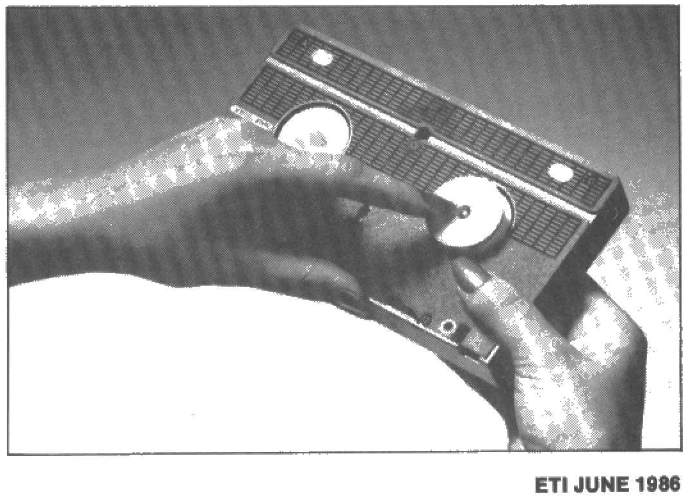
There are a number of devices on the market which will prevent unauthorised use of a video cassette recorder, but this is the first gadget we have seen which locks the cassettes themselves. It allows cassettes to be protected against accidental erasure or unauthorised viewing whilst leaving the recorder itself free to replay or record other material.

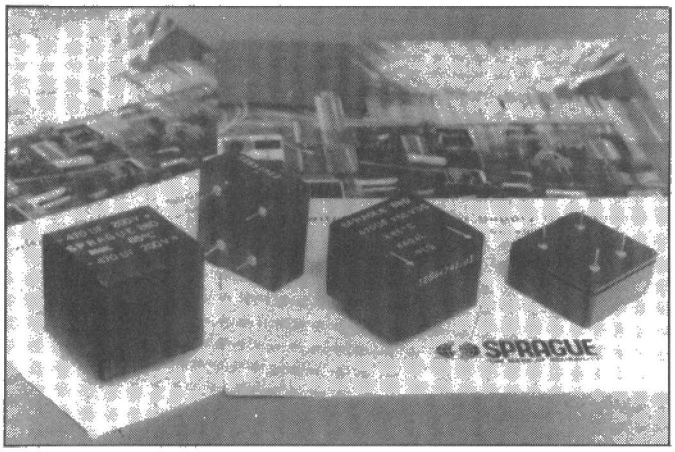
The lock consists of a plastic disc with spring-loaded tabs which clips into one of the cassette sprocket holes.

This prevents the cassette being loaded into the recorder but will not damage either the cassette or the machine. Once in place, the lock can only be removed with the key provided and the manufacturers say that any attempt to remove it by force will cause visible damage to the cassette.

The locks are brightly coloured to provide an immediate visual indication that a cassette must not be tampered with. They are supplied in packs of three with one key and the recommended retail price is £2.99. The model currently available is only suitable for use with VHS cassettes but a Beta version will be introduced shortly. They will be sold through high street newsagents and department stores.

Video Cassette Lock (UK) Ltd, PO Box 202, Leicester, tel 0533 - 555 180.





Flatpack Electrolytic Capacitors

Sprague claim that their new 88D series represents a major development in aluminium electrolytic capacitors. They offer low inductance and low equivalent series resistance (ESR) and come in flat, square packages which allow a high board packing density to be achieved.

The capacitors are available in two case sizes with values from 56u to 18000u and with voltage ratings from 3 to 450V DC. An internally connected bus bar construction enables them to withstand high ripple currents, the maximum DC load current being 25A. The equivalent series inductance is typically 4nH in a low voltage circuit and the ESR is ±30% at 25°C from 20kHz to 500kHz. The operating temperature range is from −40°C to +85°C.

Sprague expect the 88D series to find applications in the latest generation of switch-mode power supplies.

Sprague Electric UK Ltd, Airtech 2, Fleming Way, Crawley, West Sussex RH10 2YQ, tel 0293 – 517 878.

- *All owners of Avometer type 1000 and 1001 analogue multimeters are advised to check them following the discovery of a potentially dangerous fault in the design. The suspect instruments have serial numbers in which the second letter is C or D or which contain adjoining letters AE, BE, CE or DE. They will be modified quickly and free-of-charge if returned (in a package marked FOR MODIFICATION) to Thorn EMI Instruments Ltd, Parts and Service Centre, Archcliffe Road, Dover, Kent CT17 9EN, tel 0304 – 202 620.*

- **Thermalloy have introduced several new products, among them a solder-on heatsink for axial lead devices such as resistors and diodes and a clip-on T0-220 heatsink which is as efficient as many full-size, bolt-on types. They are described in the latest literature which can be obtained from MCP Electronics Ltd, 26–32 Rosemount Road, Alperton, Wembley, Middlesex HA0 4QY, tel 01-902 6146.**

- NEC's 24-page Speech Flyer covers their range of components, boards and complete systems relating to speech technology. The devices described include waveform speech synthesisers, speech processors, compressors and word recognition systems. Copies of the booklet can be obtained from NEC Electronics (UK) Ltd, Block 3, Carfin Industrial Estate, Motherwell ML1 4UL, tel 0698 – 732 221.

- **Wind-your-own kits for laminated transformers have been around for some time, but Electronics and Computer Workshop Ltd are the first company we have come across offering a kit for toroidal transformers. They offer VA ratings of 50, 120, 225, 500 and 1000 and all types are supplied with a pre-wound 250V primary. Fully inclusive prices range from £12.46 for the 50VA model to £48.76 for the 1000VA model. ECW Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, tel 0245 - 262149.**

- *A new 178-page catalogue from analogic describes their range of high precision A to D and D to A converters and associated devices. It covers their full product line and includes applications notes, glossaries of terms and 'tutorials'. Contact Jim Lewis, Operations Manager, Analogic Ltd, 68 High Street, Weybridge KT13 8BN, tel 0932 - 56011.*

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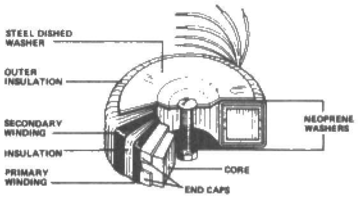

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
15VA Regulation 19% 62 x 34 (See diagram) 0.35 Kgs Mounting bolt M4 x 12	03010 03011 03012 03013 03014 03015 03016 03017	6+6 9+9 12+12 15+15 18+18 22+22 25+25 30+30	1.25 0.83 0.63 0.50 0.42 0.34 0.30 0.25
30Va Regulation 18% Size A B C 70 35 37 0.45 Kgs Mounting bolt M5 x 50	13010 13011 13012 13013 13014 13015 13016 13017	6+6 9+9 12+12 15+15 18+18 22+22 25+25 30+30	2.50 1.66 1.25 1.00 0.83 0.68 0.60 0.50
50Va Regulation 13% Size A B C 80 40 43 0.9 Kgs Mounting bolt M5 x 50	23010 23011 23012 23013 23014 23015 23016 23017 23028 23029 23030	6+6 9+9 12+12 15+15 18+18 22+22 25+25 30+30 110 220 240	4.16 2.77 2.08 1.66 1.38 1.13 1.00 0.83 0.45 0.22 0.20
80Va Regulation 12% Size A B C 95 40 43 1.0 Kgs Mounting bolt M5 x 50	33010 33011 33012 33013 33014 33015 33016 33017 33028 33029 33030	6+6 9+9 12+12 15+15 18+18 22+22 25+25 30+30 110 220 240	6.66 4.44 3.33 2.66 2.22 1.81 1.60 1.33 0.72 0.36 0.33
120VA Regulation 11% Size A B C 95 45 50 1.2 Kgs Mounting bolt M5 x 50	43010 43011 43012 43013 43014 43015 43016 43017 43018 43028 43029 43030	6+6 9+9 12+12 15+15 18+18 22+22 25+25 30+30 35+35 110 220 240	10.00 6.66 5.00 4.00 3.33 2.72 2.40 2.00 1.71 1.09 0.54 0.50

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
160VA Regulation 8% Size A B C 110 45 50 1.8 Kgs Mounting bolt M5 x 50	53011 53012 53013 53014 53015 53016 53017 53018 53026 53028 53029 53030	9+9 12+12 15+15 18+18 22+22 25+25 30+30 35+35 40+40 110 220 240	8.89 6.66 5.33 4.44 3.63 3.20 2.66 2.28 2.00 1.45 0.72 0.66
225VA Regulation 7% Size A B C 110 50 55 2.2 Kgs Mounting bolt M5 x 60	63012 63013 63014 63015 63016 63017 63018 63026 63025 63033 63028 63029 63030	12+12 15+15 18+18 22+22 25+25 30+30 35+35 40+40 45+45 50+50 110 220 240	9.38 7.50 6.25 5.11 4.50 3.75 3.21 2.81 2.50 2.25 2.04 1.02 0.93
300VA Regulation 6% Size A B C 110 57 62 2.6 Kgs Mounting bolt M5 x 60	73013 73014 73015 73016 73017 73018 73026 73025 73033 73028 73029 73030	15+15 18+18 22+22 25+25 30+30 35+35 40+40 45+45 50+50 110 220 240	10.00 8.33 6.82 6.00 5.00 4.28 3.75 3.33 3.00 2.72 1.36 1.25
500VA Regulation 5% Size A B C 135 60 65 4.0 Kgs Mounting bolt M8 x 70	83016 83017 83018 83026 83025 83033 83042 83028 83029 83030	25+25 30+30 35+35 40+40 45+45 50+50 55+55 110 220 240	10.00 8.33 7.14 6.25 5.55 5.00 4.54 4.54 2.27 2.08

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
625VA Regulation 4% Size A B C 140 70 75 5.0 Kgs Mounting bolt M8 x 90	93017 93018 93026 93025 93033 93042 93028 93029 93030	30+30 35+35 40+40 45+45 50+50 55+55 110 220 240	10.41 8.92 7.81 6.94 6.25 5.68 5.68 2.84 2.60

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30	1	9.67
50	2	10.70
80	3	11.96
120	4	12.71

VA	SERIES NO.	£
160	5	14.95
225	6	16.33
300	7	17.84
500	8	23.37
625	9	25.96

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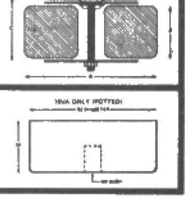


READ/WRITE

Adzap And After

Dear Sir,

You will be delighted to know that we of JESOS (Joint Effort to Save Our Sanity from adverts) have had the 'JOSEPH' injunction quashed on appeal. The circuit of the Adzap is now available together with a complementary device, the AFOO(L) iPRL. This can easily be fitted to the Adzap and removes all TBM from broadcast television. This includes the synthetic and cloned percussion sounds, non-musical repetitive drones, etc, now added to most programmes, trailers, previews, run-downs, etc. It also includes 85% of so-called pop 'music' in the content of such programmes. There is no injunction on TBM but there should be — permanently!*

Thanks for the April fool jape — pity it's not true.

Yours sincerely,
Eric A. Cook,
Hemel Hempstead.

**TBM = That Bloody Music.*

Dear Mr Eaty-Eye,

AP(R)iLFOOL, eh? Very interesting, but stupid. How to stop your VCR taping the adverts is with a zero-crossing detector connected to the TV audio and any home micro. This can spot the characteristic frequency swoops of the hysterically enthusiastic voices and will also trap many game shows, QED, Tomorrow's World, Ian MacNough What's-his-name, Blue Peter and indeed most of the stuff that you would only want to record if you were breaking in a stubborn video for somebody.

And why don't you give NEC's address? Is the 7220 a hoax too? And how long is it since you printed a picture of a naked woman? Pull your socks up or you'll go the way of Computing Age and you wouldn't want that now, would you.

Apart from that it's all good stuff and I wouldn't hesitate to recommend it to anyone.

Yours sincerely,
Tim Hunt,
Radstock,
Bath.

Dear Sir,

After reading the Adzap article in the April issue I felt I should write to you regarding Specialist Semiconductors' marketing policy.

By marketing a product which will upset the finances of established companies, Specialist has, it seems to me, severely damaged its own chances of success.

Firstly, by implementing the device solely in hardware, only advertisements can be avoided. Surely a software solution or a keypad for user input would be more advisable, allowing other types of programmes such as 'Dallasty' or Wogan to be excluded?

Secondly, Specialist seem to have totally ignored the Transmitted Signal Subsidiary Status Byte (TSSSB) which contains more detailed information rather than simply identifying the general type of programme being transmitted. For example, a person intending to buy a new car or home computer might wish to see adverts for these items only. This would be possible using TSSSB, as the following table shows:

Advert Type	**Bit 0**	**Bit 1**	**Bit 2**	**Bits 3–7**
Food/drink (including Nescafe)	0	0	0	Manufacturers identity code
Transport (including BR)	1	0	0	
Communication	0	1	0	
Music (including Sigue Sigue Sputnik)	1	1	0	
Household items	0	0	1	
Government adverts (eg., Monergy)	1	0	1	
Unused — reserved for future use	0	1	1	
April Fool messages	1	1	1	

I can only hope that Specialist use the period of the injunction to upgrade their product.

Yours faithfully,
Russell Haggar,
Potters Bar.

DES Demeaners

Dear Sir,

Having read the data encryption articles in the September 1985 and April 1986 issues of ETI, I would like to offer my own encryption system which I think is more secure than the standard DES. It works like this.

The electronic equivalent of a one-time pad would generate a random bit stream and this would then be passed through a DES IC. The resulting output would still be entirely random and would be used to encipher plaintext on a letter-by-letter basis.

The one-time bit stream previously offered to the DES would be passed through it a second time but with the use of different keys. This second batch of DES output would differ completely from the first, but would still be of random character. Further plaintext could be enciphered by this means, and the process could be repeated as often as necessary, the DES keys being changed for each transit.

The object is to use the one-time random sequence repeatedly, so obviating the normal disadvantage of the one-time method in which very large amounts of cipher material have to be prepared and stored.

Yours faithfully,
S. Cook,
Bude,
Cornwall.

We should perhaps point out to avoid confusion that if you use a random sequence more than once, it isn't 'one-time'. However, that's just a matter of terminology, and we take your point that it would be very useful to be able to generate a random sequence with the DESirable properties of a one-time pad, without the disadvantages. — Ed.

Dear Sir,

In the article 'Practical Data Encryption' in the April issue of ETI, Paul Chappell rightly states that '... you could produce similar results by writing your own routine to generate pseudo-random numbers, without using the WD2002 at all. So you can, as long as you bear in mind that the receiver of the message must be able to decrypt your message ...' But he then goes on to state, quite wrongly '... which precludes using the computer's own random number generator'.

What seems to have been forgotten is that the Beeb's RND function may be 'seeded' to enable both the sender and receiver to generate the same string of random numbers. I have devised a program which makes use of this facility which may be of interest to you (See Tech Tips — Ed).

Keep up the good work with the magazine.

Yours faithfully,
Rex Palmer,
Walton-on-Thames,
Surrey.

Paul Chappell replies:

To our surprise, the Practical Data Encryption circuit has brought in a good deal of mail from readers, many offering their own methods of generating pseudo-random numbers. The article was pitched at a very elementary level, and maybe this was a mistake in view of the grasp of the principles involved that many of our readers have shown. Perhaps a brief comment on one or two of the suggestions would be in order.

The most popular 'alternative DES' suggestion is to use the standard configuration of a shift register with feedback to generate pseudo-random strings. The sequences produced in this way have many of the 'noise-like' properties of a true random sequence, which makes them suitable for statistical problems, and so on. For data encryption, I'm afraid they are not at all suitable. The reason is that the simple method of generation yields an equally simple method of attack. If the person intercepting the encrypted message can also obtain a copy of the plaintext (by bribery?), the solution of a relatively small number of linear equations will enable them to generate the entire sequence and decrypt any subsequent messages with ease. Similar principles apply to many of the pseudo-random generators, whether in hardware or software, and I would be most surprised if the BBCs random number generator is any different in this respect. If you would like to pursue this, the paper mentioned below gives full details.

The DES algorithm itself is not a mathematically elegant process; it achieves its ends by brute force. A brief description of the process will give you an idea of its complexity, and also its crudity. The right half of the input block (32 bits) undergoes a linear transformation which results in a block of 48 bits. This is added modulo 2 to a 48 bit long subset of the key block. The result is split into eight six-bit blocks, each of which undergoes another transformation into a four-bit block. The four bit blocks are reassembled into a 32-bit block; this undergoes a permutation and is then added modulo two to the left-hand half of the original input block. The two halves are then interchanged. This process is repeated 16 times, each time with a different subset of the keyblock, using the resulting block from the previous cycle as the new input. It's a complicated process, and therein lies its only strength. It's based on the doubtful theory that the more you mess about with the input, the more difficult it will be to sort it out again. In terms of applying a simple set of linear equations to determine the sequence, this is indeed correct, but the sheer haphazardness of the process results in a number of 'weak' keys under which the data is very poorly encrypted. Having said that, I'm judging it by rather different standards from the systems mentioned earlier. Given the choice between a pseudo-random generator of the home-computer type and DES with its very weakest key, I'll take the DES!

I don't mean to disparage the efforts of amateurs in any way — after all, as far as data encryption is concerned, I am one myself! Many of the advances in modern cryptography have come about as a result of people who take an interest in the subject and look on it in a fresh, new way. But I'm afraid you'll have to look a little further than the obvious methods — they have all been considered before and discarded for very good reasons.

For details of shift-register based encrypton systems, ask your local library to get you a copy of: 'The Protection of Data by Cryptography' by D.W. Davies and D.A. Bell; National Physical Laboratory Report COM98, January 1978.

If you have any difficulty in obtaining a copy of the DES standard through your local library, it can be obtained from: Microinfo Ltd., P.O. Box 3, Hamlet House, Alton, Hants GU34 1EF (tel. Alton 84300). There will be a charge of about £4 for it — 'phone them first to make sure of the current price.

An introduction to linear binary functions (linear in this context meaning that superposition etc. is applicable), and to maximal sequences, pseudo-random sequences, and so on is: 'Binary Sequences' by G. Hoffman de Visme, published by the English Universities Press.

Sins Of Emission

Dear Sir,

I read with interest the 'thought processes' involved in the design of the John Linsley Hood portable PA, and would like to point out a slight error in Figs. 2 and 3 on page 20 (ETI April 1986). These illustrations show the DC/DC convertor used in the final design, but the symbol used to represent the Darlington pairs is incorrect. It shows two NPN transistors with their emitters connected together and the collector of the first driving the base of the second. This configuration will not work! The correct arrangement, of course, is with the two collectors connected together and the emitter of the first driving the base of the second.

I have been buying your magazine for almost a year now and consider it to be the best there is. As electronics is a major part of the course I am doing, I find some of the articles of immense value and interest. Keep up the good work.

Yours faithfully,
John Walsh,
Cork,
Ireland.

Umm! Yes, well, we're glad you spotted that! Since it was in the April issue, we could pretend it was intended to fool people. Unfortunately, some of you might start wondering who the real April Fools are ....

AUNTIE STATIC'S PROBLEM CORNER

Dear Auntie,

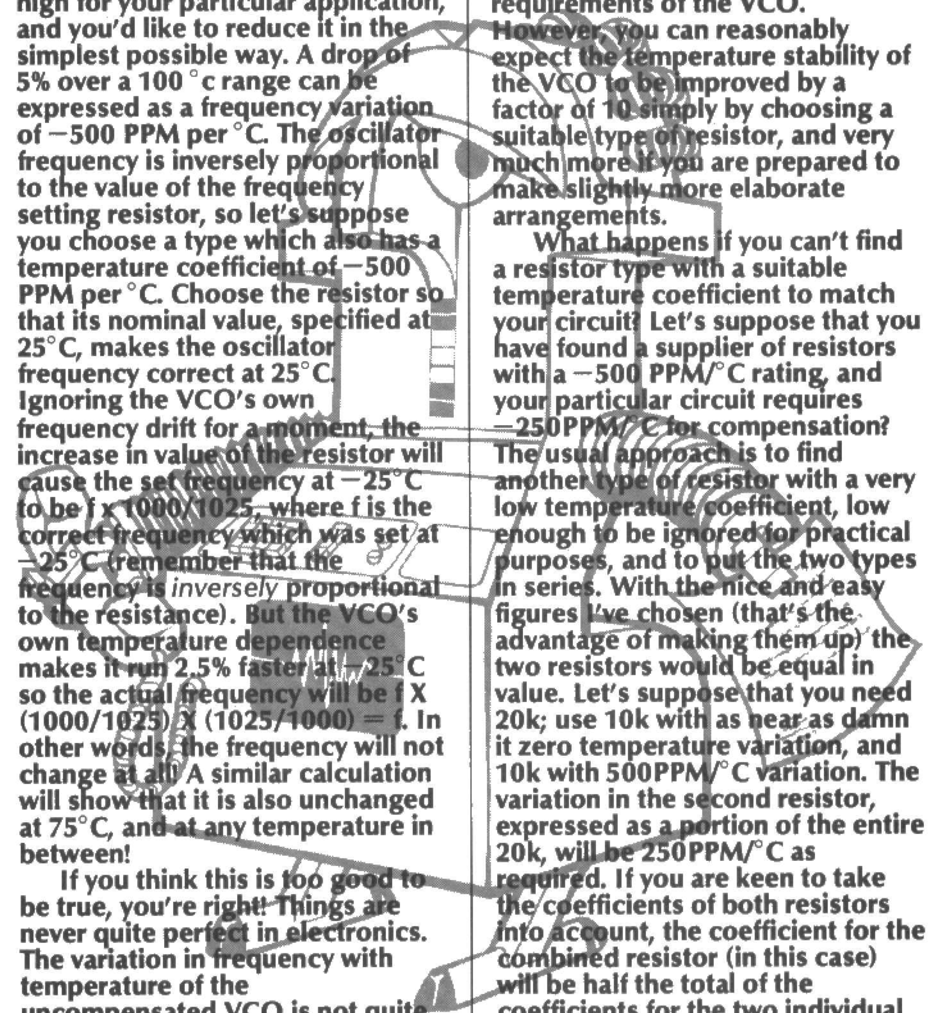
I am building a VCO which uses copper wire and metal film resistors to achieve temperature compensation in the exponential generator circuit. I would be interested to know how the series resistors values are calculated to achieve a particular temperature coefficient and what the effect of using different resistor types is.

A.J. Dolan,
Ilford,
Essex.

I'm sure all ETI readers are aware that the value of any resistor will change with variations in temperature. The extent of the variation depends on the type of resistor, and for some kinds it can be quite alarmingly high. It is not unusual for carbon composition types to have a temperature coefficient of more than ± 1000 PPM (parts per million) per °C, which means that a 1M0 resistor would change in value by 1k0 for every °C change in temperature. Carbon film types tend to be better for low values of resistance — the Mullard CR16 series, for instance, has a temperature coefficient below -300 PPM per °C for resistance values up to 10k or so. For higher resistance values, the temperature coefficient increases, and values above a few megohm can be as bad as composition types in this respect. Metal film types will often have a temperature coefficient of 50 PPM per °C or better.

With the obvious exception of thermistors, which are resistors deliberately made to have an extremely high negative temperature coefficient, the resistance variations are generally regarded as a nuisance which resistor manufacturers try to keep to an acceptably low level. In some instances, however, the effect can be useful to cancel out other temperature effects in a circuit, as in the case of your VCO.

Without knowing the details of your circuit, I can't comment on the way the resistors are used. However, if I take the VCO contained in the NE567 phase locked loop as an example it will give you an idea of the principles involved. With a supply voltage of 9V, the variation in oscillator frequency with temperature in this IC is fairly linear from −25 °C to +75 °C, and it drops by 5% over this range (from manufacturers' data). Let's suppose that this frequency change is unacceptably high for your particular application, and you'd like to reduce it in the simplest possible way. A drop of 5% over a 100 °c range can be expressed as a frequency variation of −500 PPM per °C. The oscillator frequency is inversely proportional to the value of the frequency setting resistor, so let's suppose you choose a type which also has a temperature coefficient of −500 PPM per °C. Choose the resistor so that its nominal value, specified at 25°C, makes the oscillator frequency correct at 25°C. Ignoring the VCO's own frequency drift for a moment, the increase in value of the resistor will cause the set frequency at −25°C to be f x 1000/1025, where f is the correct frequency which was set at −25°C (remember that the frequency is *inversely* proportional to the resistance). But the VCO's own temperature dependence makes it run 2.5% faster at −25°C so the actual frequency will be f X (1000/1025) X (1025/1000) = f. In other words, the frequency will not change at all! A similar calculation will show that it is also unchanged at 75°C, and at any temperature in between!



If you think this is too good to be true, you're right! Things are never quite perfect in electronics. The variation in frequency with temperature of the uncompensated VCO is not quite linear (nor will the variation in resistance be, for that matter) and production spreads mean that there will be differences in slope between one NE567 and the next. There is also the problem of finding resistors with precisely specified temperature coefficients which precisely match the requirements of the VCO. However, you can reasonably expect the temperature stability of the VCO to be improved by a factor of 10 simply by choosing a suitable type of resistor, and very much more if you are prepared to make slightly more elaborate arrangements.

What happens if you can't find a resistor type with a suitable temperature coefficient to match your circuit? Let's suppose that you have found a supplier of resistors with a −500 PPM/°C rating, and your particular circuit requires −250PPM/°C for compensation? The usual approach is to find another type of resistor with a very low temperature coefficient, low enough to be ignored for practical purposes, and to put the two types in series. With the nice and easy figures I've chosen (that's the advantage of making them up) the two resistors would be equal in value. Let's suppose that you need 20k; use 10k with as near as damn it zero temperature variation, and 10k with 500PPM/°C variation. The variation in the second resistor, expressed as a portion of the entire 20k, will be 250PPM/°C as required. If you are keen to take the coefficients of both resistors into account, the coefficient for the combined resistor (in this case) will be half the total of the coefficients for the two individual resistors.

Auntie.

PLEASE, PLEASE, PLEASE ...

Address all correspondence to the Editor, Electronics Today International, 1 Golden Square, London W1R 3AB. ASP Ltd publish a number of other magazines beside ETI, and in spite of their superior intellects and triple honours degrees our mailroom staff are frequently unable to guess the intended destination of letters addressed simply to The Editor, 1 Golden Square. Letters like this tend to end up in the offices of obscure magazines whose staff have never heard of ETI, often to lie undisturbed at the bottom of an in-tray for years!

It will also help us if you can indicate on the envelope which department the letter is intended for (Read/Write, Tech Tips, Technical Enquiries, etc) and avoid dealing with several matters in one letter. This particularly applies to letters containing money. We sometimes receive letters from people who require backnumbers, PCBs, and photocopies and enclose a single cheque to cover all three. The inevitable shuffling around between departments this entails (some of them in London and some in Hemel Hempstead) slows things down an awful lot and we suspect that most people would rather pay a little more in postage and issue several cheques in order to avoid the delay. **ETI**

RF OSCILLATORS

For those whose specialism lies elsewhere, Joe Pritchard tells all you'll ever need to know about sine wave oscillators operating at radio frequencies.

The sinusoidal oscillator is simply an amplifier which contains enough positive feedback for oscillation to be maintained. The frequency of these oscillations is set by the presence in the feedback path, or in another part of the amplifier, of a filter — usually a piezoelectric crystal or a tuned circuit made up of inductors and a capacitors — an LC circuit. These are the three fundamental parts of a sinusoidal RF oscillator: the amplifier, the feedback loop and the tuned circuit.

The Amplifier

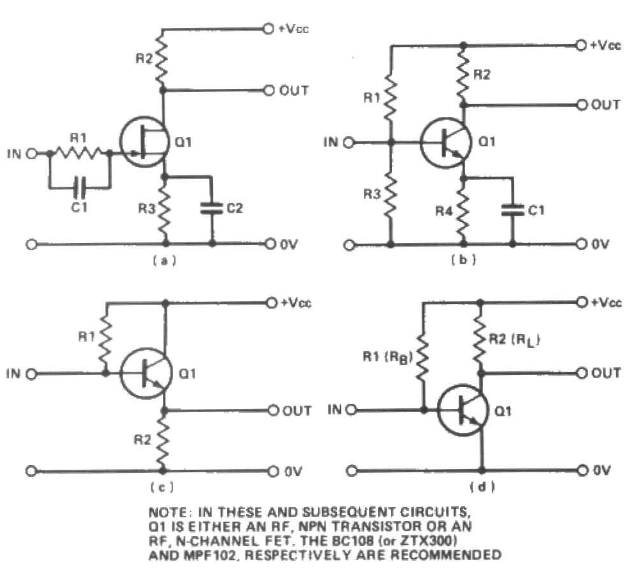
Simple RF oscillators are usually based around a single stage amplifier — like those shown in Fig. 1. Bipolar or FET devices can be used, and should be operated as simple linear amplifiers. The majority of components in most simple RF oscillators are therefore for biasing. With bipolar transistors as the active component, the aim of the biasing is to get a quiescent (no input signal) voltage across the collector and emitter (Vce) which is about half the supply voltage.

This enables the output voltage from the amplifier to swing beteen 0V and Vcc for an input that fluctuates around 0V, without distorting the waveform. The virtues of class A amplification are simplicity and low component count. Biasing arrangements should be familiar from ETI and most textbooks. Indeed, almost any single-transistor amplifier could be used as the basis of an RF amplifier, with the following provisos:

It should have voltage or current gain of more than unity where voltage or current feedback is to be used;

It should be able to operate at the appropriate frequency;

Any phase change between input and output should be borne in mind.



NOTE: IN THESE AND SUBSEQUENT CIRCUITS, Q1 IS EITHER AN RF, NPN TRANSISTOR OR AN RF, N-CHANNEL FET. THE BC108 (or ZTX300) AND MPF102, RESPECTIVELY ARE RECOMMENDED

Fig. 1 Amplifiers from the heart of oscillators . . .

The Filter

All filters serve the same purpose — to discriminate between signals of different frequencies. Inductors and crystals are commonly used in RF circuits because at high frequencies they are compact and efficient. For AF oscillators they would be too bulky.

Figure 2 shows some basic filter networks. Resonant frequency — the frequency at which the network impedance is lowest — is determined by the dimensions of the inductors, capacitors and crystals used. For an LC circuit, it is given by:

$$f_{req} + ½\mu\sqrt{LC}$$

In a perfect world, no other frequencies would get through the filter. A good quality real filter will pass very few additional frequencies and a measure of quality is the Q of the filter (Fig. 3). A high Q is desirable in any tuned circuit where signals of mainly one frequency are required. Although Q depends on component values, it can be modified by the way in which the filter is connected, or coupled, to the rest of a circuit.

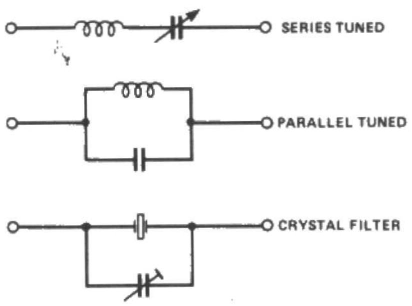


Fig. 2 . . . filter networks are their nerves.

For example, connecting the network across a relatively low impedance increases Q. In bipolar circuits, especially for LC filters, the coupling between filter and amplifier input is often more complicated. For example, taps on the coil are sometimes used to reduce the loading of the filter by the amplifier.

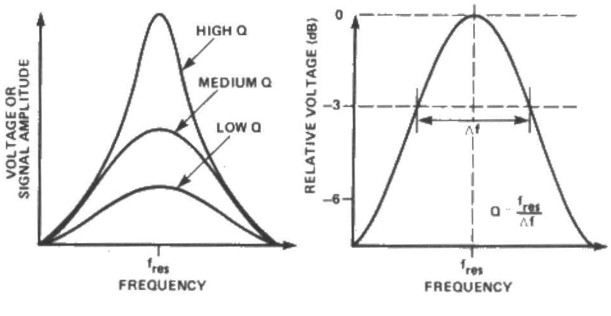


Fig. 3 Q is independent of resonance.

Leaving circuit configuration aside for the time being, the Q of a tuned circuit using coils and capacitors is limited by the losses in the tuned circuit. Most of these losses arise due to the resistance of the coil, and the Q of a coil can be approximated by:

$$Q_{coil} = 2\pi fl/R$$

where R is the DC resistance of the coil.

The Q of a coil can vary from one to a few hundred, that of a capacitor from 100 to 10,000. The Q of a crystal can be as high as 40,000. The Q of a filter or element of a filter is the ratio of its reactance at a particular frequency to its resistance. Due to the very high resistance of good capacitors, most of our losses in Q will be due to the coil. The high Q of a crystal allows us to be a little less particular about coupling it to an amplifier — even component values display wide tolerance.

Figure 4 shows one possible coupling arrangement of filter and amplifier. On switch on, small noise voltages in the circuit will be amplified and will appear at the output. Due to the tuned circuit, noise within the resonant band of frequencies will be preferentially amplified. Feedback is a means of sustaining this amplification and building on it.

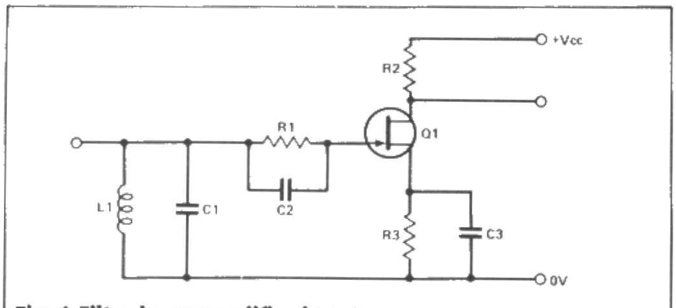


Fig. 4 Filter in an amplifier input.

The Feedback Loop

Part of the output signal must be fed back to the input in such a way as to reinforce the signal. As well as being of the correct frequency, the feedback must be in phase with the input signal. In the Fig. 4 circuit, the feedback path must introduce a phase change — the amplifier itself making good any losses that occur in the circuit.

Two types of feedback loop are shown in Fig. 5. In fig. 5a, LP provides feedback. Providing the appropriate phase change is simply a matter of which way round the coils are wound and connected. The distance between L1 and LF determines the amount of feedback introduced in the circuit. This should be the minimum required for steady oscillation, but it will vary with the frequency of operation. Figure 5b is the same basic circuit but with the variable capacitor, CV1, providing control over the amount of feedback.

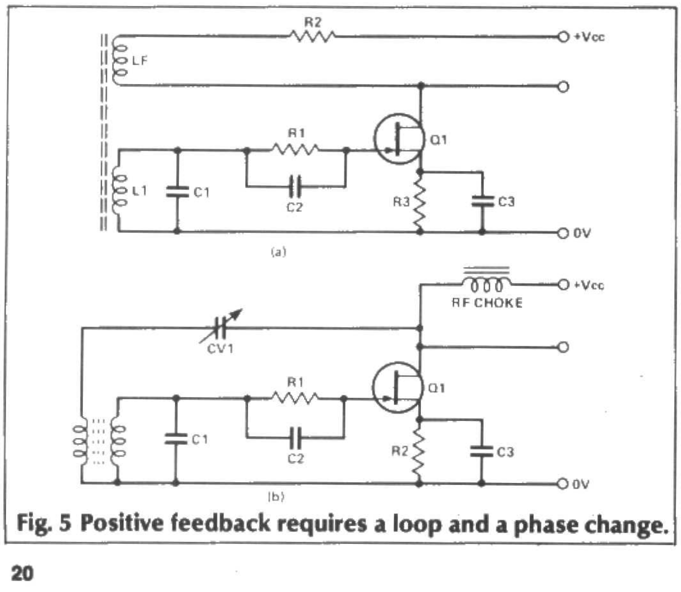


Fig. 5 Positive feedback requires a loop and a phase change.

This circuit is virtually a regenerative radio receiver — an amplifier brought just below the threshold of oscillation, the point at which it gives maximum gain.

A feedback loop can be purely capacitive, which means that the amount of feedback could be adjusted with a variable capacitor allowing for different transistor characteristics. Variability is also required if the circuit is to be operated over a wide range of frequencies, as the amount of feedback required to sustain oscillation in some circuits is frequency dependent. Some RF circuits don't appear to have a feedback path at all. In these, feedback is often provided via the internal capacitances of the transistor used in the amplifier.

Oscillators

A healthy circuit should produce at its output a signal of the desired frequency which is reasonably stable, has a good waveform and is without other frequencies present. Even a good oscillator may fall down in one of these areas. So, before we go on to look at some actual circuits, let's examine some of the problems to look out for.

Drift: This is a slow variation, up or down, in frequency of oscillation. It can be caused by ageing of components in the circuit or, more often, by temperature changes. As the circuit warms up (literally) we can expect slight variations in frequency. These can be compensated for, but applications requiring high frequency accuracy demand a temperature controlled environment. The ageing problem can only really be compensated for by using a high Q filter and good quality parts in the first place.

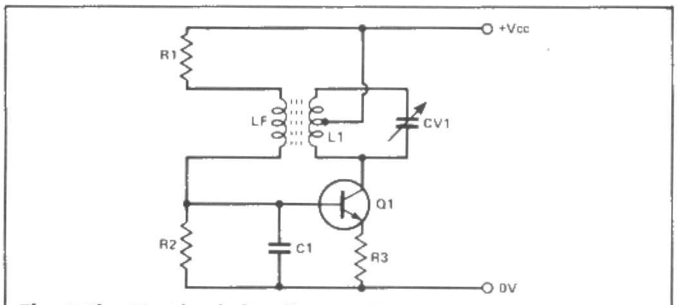


Fig. 6 The Hartley is hardly a VFO!

Pulling: This refers to the slight alteration in operating frequency that can occur if a circuit being driven by the oscillator loads the oscillator and actually changes operating characteristics. This can be avoided by not taking signals from the feedback path of the oscillator, using loose coupling between driven circuit and the oscillator or using a buffer amplifier.

Frequency Dependence of Output: Some oscillators, such as the version of the Hartley oscillator shown in Fig. 6, suffer from a variation in the output voltage with the frequency of operation. The simple answer to this is not to use such circuits for variable frequency oscillators!

Mechanical Instability: Construction techniques must ensure that there is no variation of frequency or output voltage with mechanical vibration of the type that the circuit is likely to get in use.

High Harmonic Output: The signal generated by the circuit at the frequency set by the filter used is called the fundamental frequency of the oscillator. However, outputs may also be given at frequencies which are exact multiples of the fundamental. These are the harmonics of the signal, and in most cases we want to try and reduce them. The size of these harmonics usually decreases as their order increases. They are usually caused by non-linearity within the amplifier stage. This may be caused by poor construction. Dry solder joints can act as a semiconductor diode, and the resultant non-linearity can cause such problems. In some cases, of course, (square-wave generators, for example) harmonics are desirable.

High Noise: Noisy transistors will introduce noise voltages to the amplifier, and this may widen the band of frequencies generated by the oscillator, effectively decreasing Q. This noise effect is likely to be important only in circuits with very high Q. In general, FET devices have a lower noise than bipolar transistors.

Distortion: Distortion can be reduced by ensuring that the amplifier isn't operated in a non-linear fashion. One cause of this not dealt with above (High Harmonic Output) is excessive feedback, making the amplifier saturate. Reducing feedback to a level compatible with reliable oscillation is a good idea. High Q circuits and loose coupling of the oscillator to other circuits will also help.

Crystal Oscillators

Crystals provide us with a very stable source of RF signals capable of producing almost any suitable frequency up to about 20MHz. The limit isn't arbitrary — it's just that a crystal whose fundamental frequency is this high is only about 0.1mm thick!

Crystals can produce signals of even higher frequencies. We could, for example, use a circuit to generate harmonics of a lower frequency crystal and then tune following circuitry to select the desired harmonic, or we could use a technique by which the crystal is caused to oscillate at a frequency near one of its odd harmonics. Special crystals are available which do this in preference to vibrating at the fundamental, called overtone crystals. They allow crystal control at VHF (They are called overtone frequency crystals, not harmonic frequency crystals, because the crystal doesn't vibrate at an exact harmonic frequency.)

A crystal is a mechanical device that, when excited by an alternating voltage at close to its resonant frequency, vibrates in sympathy. It can also be viewed as a high Q tuned circuit, as shown in Fig. 7. Crystals have two frequencies at which their electrical characteristics change. At f1, the impedance drops to DC resistance, R. This is called the Series Resonant Frequency. At f2, the crystal acts as a parallel tuned circuit, and the frequency is the Parallel Resonant Frequency. These frequencies are within 1% of each other.

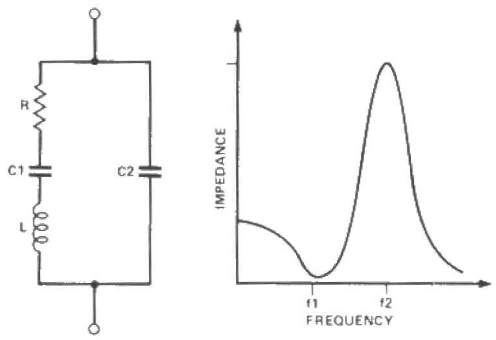
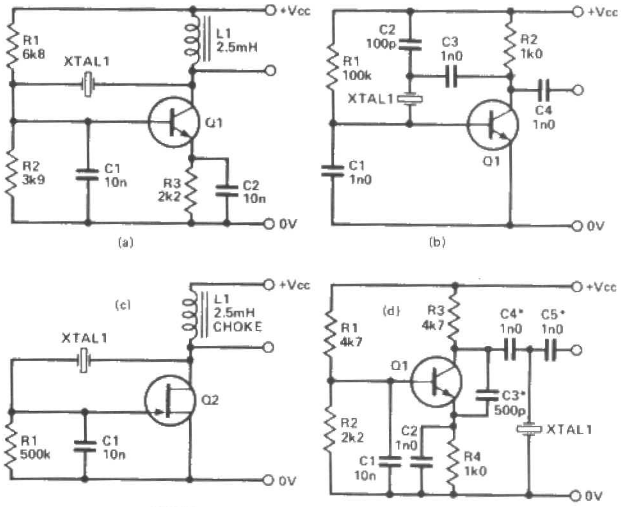


Fig. 7 This should be crystal clear.

The circuits in Fig. 8 are typical of simple crystal oscillators In Fig. 8a, the crystal provides both feedback and filter. The RF choke provides a load resistance at radio frequencies, and ensures that the crystal is the only path for the RF voltages amplified by the transistor.

Fig. 8 b is a useful circuit for marking the lower end of the 80m Amateur band. The coupling between the circuit and the receiver being set up should be kept loose. In many cases the signal can be transferred from oscillator to receiver by wrapping a piece of insulated wire from the output of the oscillator around the aerial input of the receiver!



NOTES:
XTAL1 = 3.579MHz
* = EXACT VALUES VARY WITH CRYSTAL

Fig. 8 Simple crystal oscillators.

Possible Problems

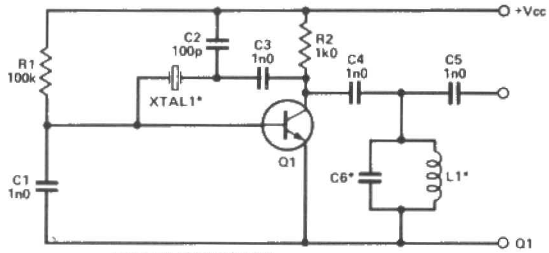
There aren't many with crystal oscillators, providing that the crystal is reasonably active at the frequency of interest. Although designed to produce a fixed frequency, it's possible to slightly detune a crystal around its designated frequency by putting a trimmer capacitor of 15 to 25pF across it. This is necessary in applications where absolute accuracy of frequency is needed. The trimmer can adjust the crystal oscillator until it is spot on.

Crystals do age, which is one cause of loss of activity. Violent mechanical shock or excess heating can also damage crystals, so be careful with that soldering iron! The frequency of oscillation of a crystal can also vary with ambient temperature, but only by a small amount. The amount of frequency change is measured in terms of parts per million per degree centigrade, or ppm/°C for short. It can be positive, which indicates that an increase in temperature will lead to an increase in frequency, or negative.

The actual drift for a given crystal depends upon the way in which the crystal was cut, or manufactured. The cuts know as AT, BT and GT are best in this respect, having very low or zero drifts. The AT and BT crystals can work at frequencies of up to eight and 20MHz, respectively. GT is limited to frequencies up to 500kHz. The worst drifts that you're liable to meet are fromthe cuts known as X and Y, which have drifts of around -25ppm/°C and +75 ppm/°C, respectively.

Temperature dependency can be exacerbated by the presence of high currents flowing through the crystal at the resonant frequency. Some oscillators are designed to be used in ovens, thermostatically controlled boxes to keep the crystal at a constant temperature.

Figure 9 shows a circuit in which both crystal and LC filters are used. The biasing arrangement is such that harmonics will be generated. The circuit across the output can be tuned to an harmonic frequency. This is, in fact, a simple form of frequency multiplication.



* TUNED COMPONENTS

Fig. 9 This circuit will produced harmonics.

Figure 10 shows a circuit that gives a *very* high harmonic output, and demonstrates a further method of producing an RF signal when the waveform isn't important. Square waves are easily produced by logic or switching circuits, and generate an absolute swarm of harmonics. This circuit is a simple calibrator, generating frequencies at 1MHz and 100kHz which can be used roughly to calibrate short wave receivers. A 10kHz marker could easily be provided by adding a further 7490 (IC2).

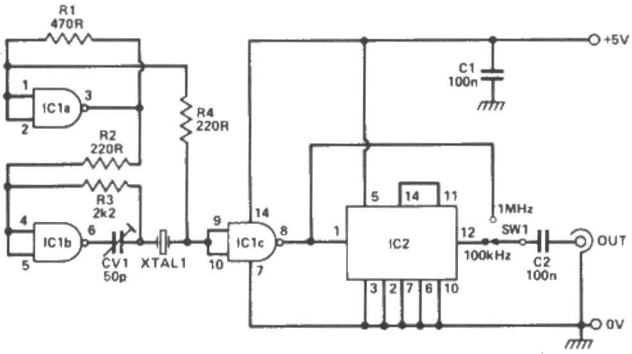


Fig. 10 Multivibrators are just harmonically rich.

Setting up the circuit for accurate 1MHz operation is fairly simple. Select the 100kHz marker, which will generate harmonics at 200kHz longwave. Loosely couple the output from the circuit to the radio — just standing the calibrator next to the set will often provide a sufficient signal. You'll probably hear a whistle. Now adjust CV1 until the whistle disappears. The calibrator is set. The harmonics from this circuit are audible to well above 30MHz.

LC Oscillators

The filter in an LC circuit is made from a capcitor and an inductor. If a variable frequency is required, it's most convenient to use a variable capacitor. Again, there are a variety of circuit configurations that an LC oscillator can be based on, and here we'll only discuss the best known types.

No matter how good an LC filter is, it will always be less efficient than crystal filters. They can still be very good, provided that a few pointers are followed.

Most of the losses in a LC filter will come from the coil, so this should be as good as possible. You'll find it convenient to wind your own for many applications, as you can't just buy particular inductance values like you can resistors! An approximate value of the inductance of a coil is given by:

$$L + a^2N^2/4d$$

where N is the number of turns, L is the inductance in microhenries, d is the length of the winding in centimetres and a is the radius of the winding in centimetres. The equation can be rearranged to give the number of turns for a particular inductance. If this approach is used, a wire diameter must be chosen to give a suitable winding length. The equation is useful, but needs a little trial and error in it's application. It is meant for single layer coils only. It also applies to core-less coils. A ferrite core will tend to increase the inductance of a given coil and a brass core will reduce it. A useful approach to coil design is to construct a coil smaller than that required, then bring it to the appropriate value using a core. This can be adjusted until the filter is resonant at the frequency of interest.

The coil should have a low DC resistance. Thicker wire, or Lizst wire, which is many stranded wire, are preferred. Both these give low losses. The former on which the coil is wound should be non-metallic, for similar reasons of low loss. It should also be rigid, so one of the rigid plastics is suitable. For reliable and accurate work, wood is no good and neither are the 'softer' plastics such as PVC. Apart from the construction techniques used in the coil, the inductance can be modified by mechanical vibration causing the turns of the coil to vibrate and move with respect to one another. This is easily dealt with by using something like Bostik to stick the turns down or by having a former with ridges in to hold the turns rigid. On a similar type of problem, coils wound of thick wire can be self supporting. You can occasionally get slight fluctuations in frequency if the temperature changes as the copper used in the coil expands and contracts.

To prevent losses from the coil, it should be positioned on the circuit board at least two coil diameters from other components. This is another good reason for making small coils. You can also screen the coil with a metal can, though this will cause a slight difference in the inductance of the coil.

Finally, if a core is used, ensure that it is a tight fit within the former so that it doesn't wobble. This would have a radical effect on the coil inductance and hence on the frequency of operation. The core, if ferrite, should only be adjusted with a suitable tool. It should be non metallic, as this would affect the inductance as well as the act of adjusting the core — not very useful if the coil's inductance changes when you remove the tool! Secondly, ferrite cores are fragile, and it's possible to shatter a core if you are careless in adjusting it.

As to the tuning capacitor, whether fixed or variable, it should be high quality device with a low variation of capacitance with temperature. For fixed capacitors, ceramic or mica components are best. For variable devices, air spaced capacitors are superior to the ones with solid dielectric. They should also be kept scrupulously clean, as grit on the plates of the capacitor can cause variations in capacitance as the capacitor is adjusted in addition to the expected frequency change. These frequency scintillations are random and very annoying

They should be rigidly mounted, and are often equipped with an extension spindle and a slow motion drive, thus allowing very fine adjustments in frequency to be made. Variable capacitors will also have temperature problems, due to the contraction and expansion of the vanes. This can be counteracted by the use of special capacitors.

For example, if a capacitor has a positive temperature coefficient (it's capacity increases with temperature) then a unit with a negative temperature coefficient (capacity decreases with increasing temperature) can be connected in parallel with it. If the compensating capacitor has roughly the same magnitude of capacitance change with temperature as the main capacitor, varying only with direction, then the temperature effects can be almost nulled out.

Types Of LC Oscillator

Figure 11 shows two alternative arrangements of the Hartley oscillator. The main characteristic of the Hartley Oscillator is that the tuning coil is tapped part way along it's length, the ratio of L1 to L2 having an effect on the circuit behaviour. The frequency of oscillation is theoretically set by equation:

$$f = 1/2\pi\sqrt{(L1 + L2)\ CV1}$$

but the values of resistors used in the biasing arrangements can have some effect on frequency. Generally, R1 should be kept as high as possible.

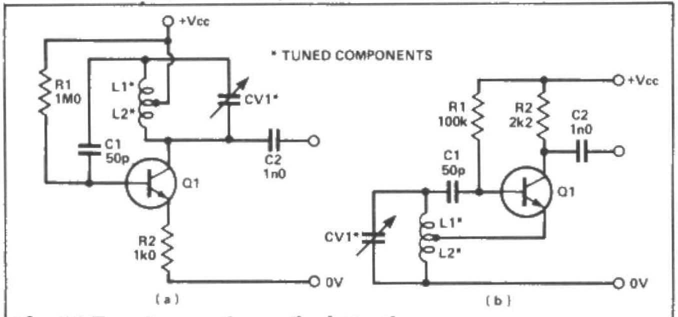


Fig. 11 Two types of practical Hartley.

In both cases, the degree of coupling between filter and amplifier is set by C1, and this should be set as small as possible to give loose coupling. A trimmer can be used here if desired. The value required is frequency dependant to some extent. C2 serves to couple the output of the oscillator to other circuits, and should be as small a value of capaitance as possible so as not to load the oscillator too much. An alternative method of removing a signal from the oscillator is to wind an additional coil on to the former of L1 and L2. The signal will be available from this winding.

A circuit that is in many ways similar to the Hartley Oscillator is the Colpitts circuit; here the filter is again tapped, but this the tap is in the capacitive part of the tuned circuit. This is shown in Figure 12. Here, R1, R2, R3 and C5 form the biasing arrangement of the circuit. C3 provides the feedback path and so should be reasonably small to provide, as in the Hartley circuit, the minimum amount of feedback needed to sustain oscillation. The frequency of oscillation is given by:

$$F = 1/(2\pi\sqrt{(L/C1) + (L/C2)})$$

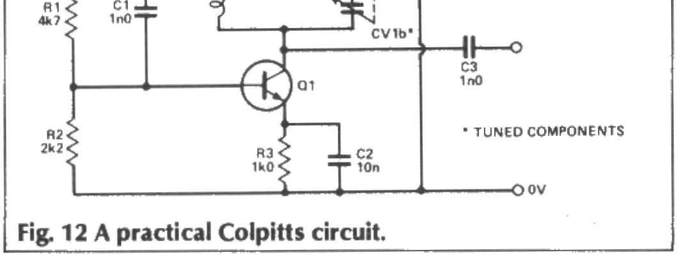


Fig. 12 A practical Colpitts circuit.

Both the Colpitts and the Hartley configurations are good, general purpose circuits, providing reasonable stability, good output level and a reasonable span of frequency change for a given coil/variable capacitor combination. Possible points to consider when you're trying to decide which to use are as follows. The Colpitts circuit is better for applications where plug in coils are used to produce a wide ranging VFO; the coils only need two connections, not three. However, the Colpitts oscillator may need a two gang tuning capacitor if the full range possible for a given coil is to be tuned. A third popular LC oscillator is the Clapp circuit, shown in Figure 13. It is effectively a modified Colpitts circuit, in which the modifications serve to reduce the loading of the tuned circuit by the amplifier. Another feature of the circuit is that for a given variable capacitor/coil configuration, the range of frequencies tuned is not as wide as with the Hartley or Colpitts circuits.

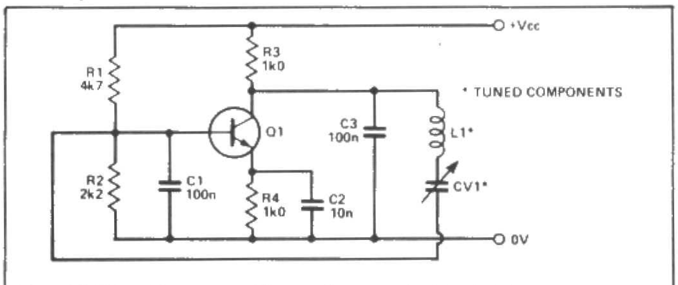


Fig. 13 The Clapp oscillator is a sort of hybrid.

There are other configurations, of course, and many of the crystal oscillator circuits we've seen will work in an LC circuit if the crystal is replaced by a tuned circuit (and vice versa). Figure 14 shows the basic circuits of Hartley, Colpitts and Clapp oscillators, taking no account of DC conditions.

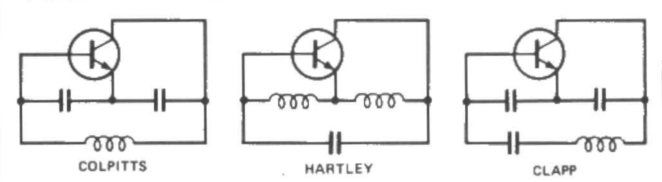


Fig. 14 Basic LC oscillator types.

Practical Pointers

Mechanical construction of such units should be rigid. Hanging components between terminals on tag strips isn't really suitable. Tuning filter components should be kept as far as is practicable from magnetic fields or heat sources, and some RF oscillators, especially those for use in radio transmitters or high accuracy RF signal generators, are built in to metal boxes with only the power and signal leads coming out. Care should be taken to keep coils away from metallic objects to cut down losses, and so it's often not a good idea to try and cram an RF oscillator in to a small a space as possible, as this can introduce losses and can lead to unwanted feedback in the circuit.

Fluctuations in the power supply voltage can cause changes in the frequency generated, and so this should be stabilised. A suitable Zener diode and current limiting resistor across the power supply will stabilise the supply voltage. Also, the supply to the oscillator should be decoupled with a ceramic capacitor (10 — 100n) to prevent RF currents circulating around the rest of the circuits of the equipment. On a similar track, any connections to electrical ground should be brought to one place wherever possible.

ETI

FIBRE OPTICS AND LASERS

Having looked at lasers and other light sources in last month's article, Roger Bond moves on to consider light detectors and the optical fibres used in communications systems.

It is alright to use lasers for burning holes in metals, but if they are to be used for communications we need a suitable detector to act as a receiver.

The two most commonly used detectors are avalanche photo diodes (APDs) and positive negative intrinsic (PIN) diodes. The former have gains of up to 1000 whereas PINs have gains of only up to 100. Gains of 100 are adequate for most applications and PINs respond faster than APDs. The weak signal is boosted by using FET amplifiers immediately after the detector.

PIN detectors consist of a sandwich of positive and negative layers between which is an intrinsic layer of low concentration N-type impurity. A good detector will have low capacitance in order to speed the signal through and this can be achieved by increasing the thickness of the intrinsic laser. On the other hand, the thicker the intrinsic layer is, the greater the leakage current. In practice an intrinsic layer of 100 um is used. The total chip size is the same as for lasers, about 400 um square.

In N-type material electrons are the majority carriers and holes the minority carriers. The opposite is true for P-type material. If a reverse bias is applied to the junction, only the minority carriers will flow across it. The result is to clear the minority carriers to the majority side, creating a depletion region. This depletion region speeds the signal across the detector junction and is called the reach through effect.

The structure of an APD detector is shown in Fig. 1a. Electrons in the N+ region can start an avalanche and to assist this, the junction is located close to the surface to catch the light. A guard ring is included to protect the junction against strong fields which could damage it.

Figure 1b shows the characteristic of an APD. The forward voltage-current characteristic shows no change in the presence of light and is therefore of no practical use. However in the reverse direction the characteristic exhibits a slope when exposed to light.

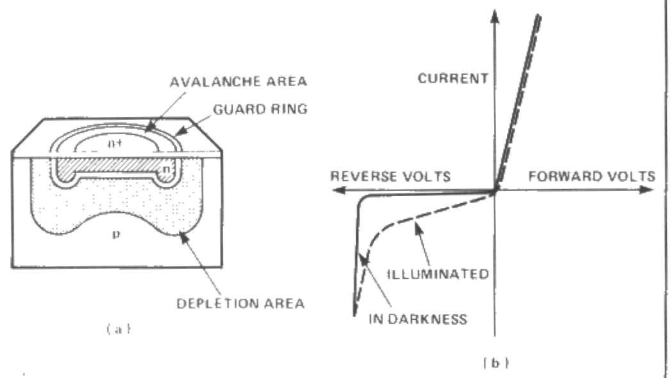


Fig. 1 The construction and voltage/current characteristics of an avalanche photodiode (APD).

In order to operate the diode in this reverse mode, high DC voltages are required, typically 100V. This is unfortunate since DC voltages require thicker conductors than AC voltages. Where APDs are used in repeaters on optical fibre links these voltages must be fed out on conventional metal conductors.

One further characteristic of a detector which is of importance is the dark current. This is the leakage current which flows through the diode when it is not exposed to light. The dark current represents a threshold, and any signal below this level will be lost. Germanium APDs have higher dark current than silicon APDs but they can be used at longer wavelengths. Typical wavelengths for communications purposes are 0.85 um, 1.3 um and 1.55 um. Silicon APDs are sufficient for the lowest wavelength but at 1.3 um and 1.5 um, germanium APDs are needed.

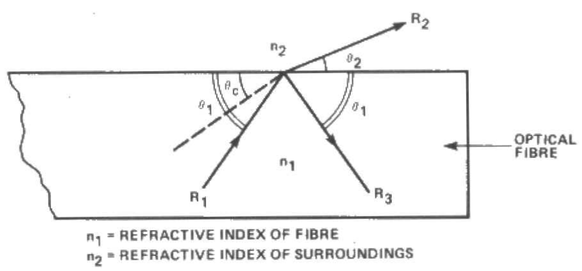

R2
n2
θ2
θc
θ1
θ1
n1
R1
R3
OPTICAL FIBRE
n1 = REFRACTIVE INDEX OF FIBRE
n2 = REFRACTIVE INDEX OF SURROUNDINGS

Fig. 2 Reflection and refraction in an optical fibre.

Optical Fibres

If light is to be used as a carrier of information then a suitable medium must be chosen. What better choice than glass? Optical fibre is just that, pure glass with chemical impurities and physical deformities removed.

The propagation of light down an optical fibre involves consideration of both refraction, reflection and refractive index. From Fig. 2, it can be seen that an internal ray of light striking the circumference of a fibre will either be reflected inwards or refracted out. It will be reflected if it makes an angle with the fibre wall greater than a critical angle θc. All the power will then be retained within the fibre.

If the fibre is covered with material of refractive index higher than the fibre then some of the power is refracted out of the fibre into the ray R2. Total internal reflection can be regained by decreasing the angle $\theta1$. Conversely, if the fibre is covered in material of a lower refractive index than the fibre, rays making angles greater than $\theta1$ will be reflected internally and power will be retained within the fibre.

Optical fibres are usually manufactured by one of two main methods, the double crucible method and the Corning method.

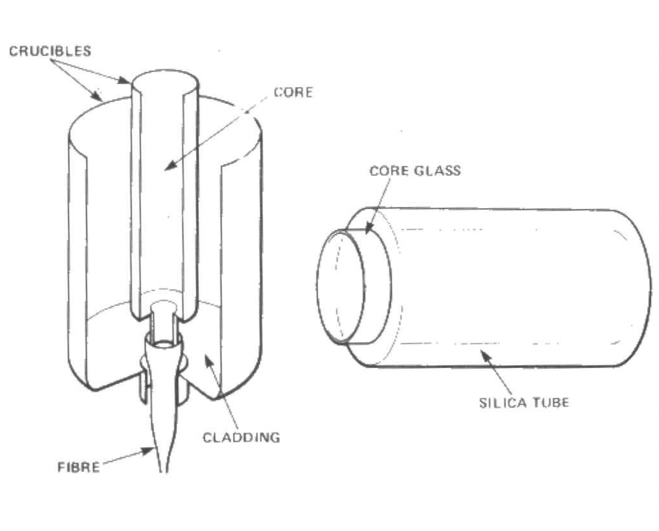


Fig. 3 (left) The double crucible method of manufacturing optical fibres and Fig. 4 (right) the Corning method.

Figure 3 shows the double crucible method. Pure glass to form the cladding is placed in the outer crucible and doped glass (to give it a higher refractive index) is placed in the inner crucible. Originally a platinum crucible was used but the glass absorbed impurities from the crucible. To overcome this, a 5MHz field is created across the molten glass. This allows the process to take place at 130°K, less than the temperature that would be required without the RF field, and a silica crucible can then be used. The composite fibre is pulled gently from the bottom of the crucible.

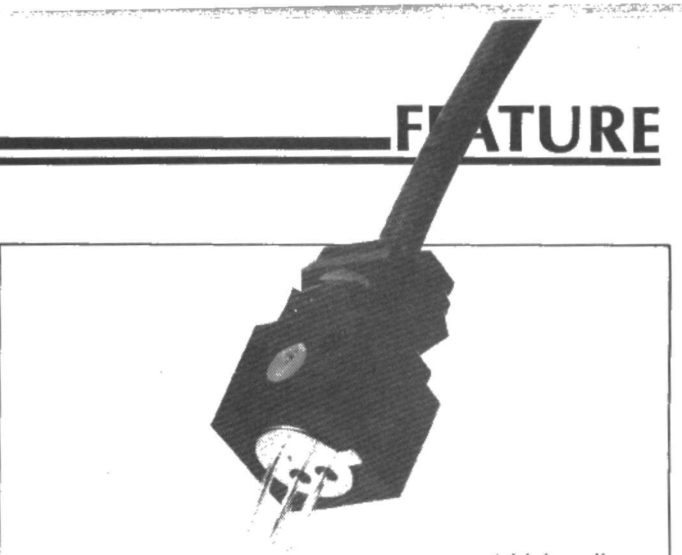
The principle of the Corning method is shown in Fig. 4. An oxygen flame is used to deposit the cladding on the inside surface of a hollow tube, then the core is deposited, again using the oxygen flame. To give the core a higher refractive index than the cladding, silica doped with the oxides of titanium, phosphorous, germanium or aluminium is used. This tube is then collapsed into a fibre.

A variation of the Corning method is to use a starting rod and deposit glass on the end. Another variation is to use a rotating mandrel and deposit the core on it, then the cladding. This is the opposite process to the hollow tube method described above.

Propagation Modes

The three methods of light propagation currently used with optical fibres are known as monomode, multimode and graded index. They are illustrated in Fig. 5.

In monomode propagation, the light used must be of a single frequency. This demands a laser because the output from LEDs contains more than one frequency. Propagation is to all intents and purposes straight down the centre of the fibre with little reflection or bouncing. Because of this, the signal travels very quickly and a comparatively narrow fibre can be used. The core diameter of a typical fibre for use in monomode applications would be about 6um.



A high-radiance infra-red LED with pluggable fibre tail (Honeywell Control Systems Ltd).

In multimode propagation, a light source which emits at more than one frequency is used. This would normally be a LED which, as we noted last month, produces light over a bandwidth of about 20nm compared with the 1nm bandwidth of a laser. The result of using several light frequencies is that each travels by a different path, some travelling straight down the centre of the fibre while others bounce back and forth between the side walls of the fibre at different rates. Because of this, some components of the signal will travel more quickly than others and will arrive at the detector earlier.

Because a number of different paths are taken by the multimode signal, the optical fibres used must be of a larger diameter than those which suffice in monomode operation. The core diameter usually employed is about 50um, and as we noted last month, some types of LEDs are manufactured with a 50um indent in the top to allow a simple and optically-efficient connection to be made to the fibre. By comparison, the small cores used in monomode propagation are quite difficult to align when jointing fibres.

The main operational difference between the two systems is the bandwidth available for modulation. Because multimode propagation involves the use of more than one frequency, the useful bandwidth is limited. Imagine, for example, an audio signal at 10kHz. If it is a pure frequency, it can be modulated with any other frequency below 10kHz without difficulty. However, if the frequency is not a pure one and there are side-

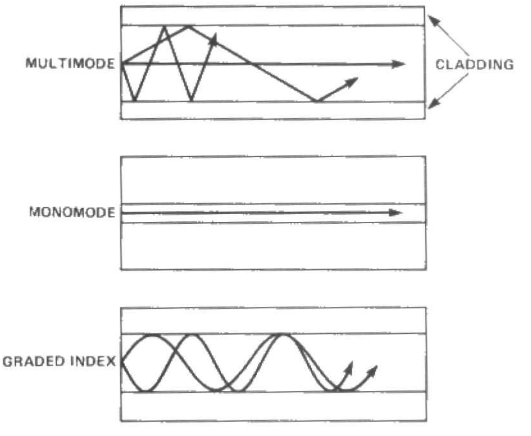
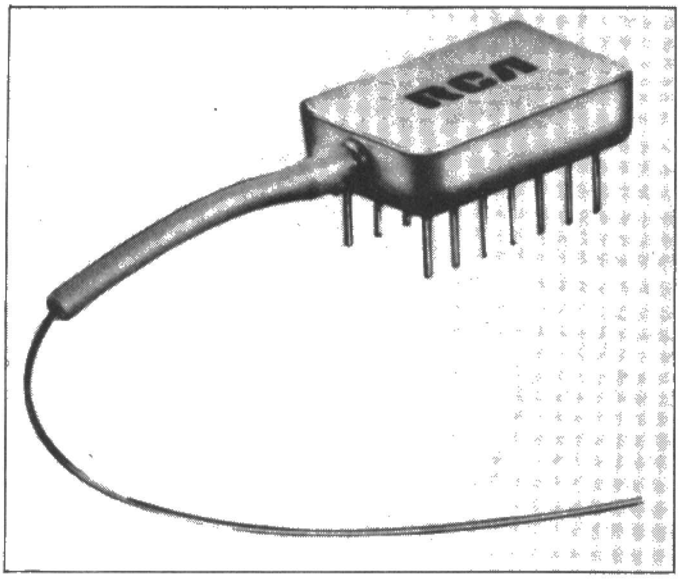


Fig. 5 The three principal types of optical fibre showing the method of propagation used in each.



A PIN photodiode with internal preamplifier (RCA).

tones present, these will also be modulated and the maximum available bandwidth will be limited to the difference between these side-tones and the fundamental. On a 10kHz signal with side-tones at, say 9kHz and 11kHz , using a modulating frequency of more than 1kHz will cause the modulation on these sidebands to overlap, and it will then be impossible to correctly extract the modulation signal at the detector.

Both monomode and multimode propagation use optical fibres in which there is a sharp difference in refractive index between the cladding and the core. In general, the refractive index of the cladding material will be about 1.5% lower than that of the core. In the third propagation system illustrated in Fig. 5, graded index propagation, this sharp change does not exist. Instead, the junction between the core and the cladding is doped so that there is a gradual change of index, hence the name. This has the effect of bending the rays as they approach the cladding rather than reflecting them. Graded index propagation represents a compromise between the systems used in the other two modes. Graded index fibres can be manufactured using either of the processes described earlier, the doping impurities being allowed to diffuse through both core and cladding uniformly.

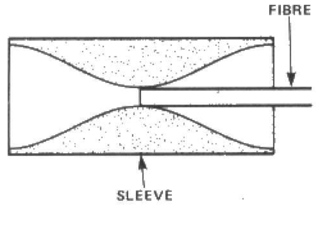


Fig. 6 Butt-jointing of optical fibres using a glass sleeve.

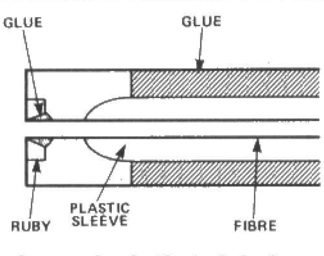


Fig. 7 An alternative method of butt-jointing using a jewel in a steel ferrule.

Loss In Fibres

The principal causes of loss in optical fibres are scattering and absorption of the light.

Scattering is caused by physical deformities in the glass which change its refractive index (Raleigh Scatter). Physical deformities also arise due to bubbles of air or water. Both can be dispelled by boiling the glass before turning it into fibre. Once the fibre has been produced nothing can be done, hence the necessity for starting with pure glass. Unfortunately, scatter loss occurs around 0.85 um to 0.95 um, which is the wavelength over which present communications systems operate.

Absorption takes place because of chemical impurities in the glass. Metal oxides each give their characteristic hues. Rubies are red because the chrome impurity absorbs all the other colours except red. Similarly, titanium causes sapphires to appear blue and iron oxide will give a green hue. Any chemical impurity will cause some part of the colour spectrum to be absorbed, leading to losses.

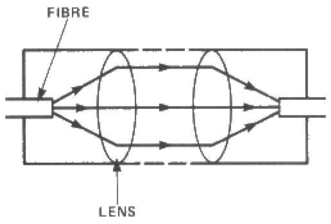


Fig. 8 Jointing two optical fibres using lenses.

From the above it can be seen that physical deformities and chemical impurities must not be introduced into the fibre during manufacture, and if there are any impurities in the raw materials, they must be extracted before the material is used.

Fibre Jointing

The most common and obvious method of jointing is to butt two fibres up close to each other or butt joint and fuse them together. A third method is to uses lenses so that the fibre is mounted at the focal point of the lens.

In butt jointing, the mating faces must be vertical and without blemishes and irregularities. There are times when fibres need to be joined in the field, and a special tool is used to give a nice clean cut. A glass sleeve can be used to keep the fibres together (Fig. 6). One end of the sleeve receives a fibre and is heat shrunk to grip the fibre. The other fibre can then be cemented in.

Another type of butt joint uses a steel ferrule and a watchmaker's jewel. These jewels are fairly cheap, and the big advantage is that holes of the correct size can be drilled in them more accurately than in other materials. Figure 7 shows the arrangement. The fibre surface is flush with the jewel surface.

If a fibre is to be 'welded' to another, the cores must be aligned. A core may not be exactly concentric with its cladding, but it does not matter if the cladding is not aligned. As a first approximation, micrometer gauges can be used to align the fibres by the cladding, but with 6 um cores in monomode fibres, even slight misalignment could mean wasted power. So as a second approximation, light can be shone through the joint and the coupling efficiency checked using a microprocessor. Small corrections are made, then a spark discharged across the joint and the fibres fused. The equipment to do all this is available and it need not be bulky. The unit developed by BICC, for example, is only the size of a small case.

Lens joints are manufactured in a factory for later assembly in the field. Each joint comes in two halves (Fig. 8), with each fibre mounted at the focal point of its lens. The whole contraption screws together when needed.

The above are all examples of fibre to fibre joints, but the same ideas apply in jointing fibres to light sources or light detectors. Butt jointing can be used, as in the case described earlier where a diode is made with a 50 um well so that it can take a 50 um multimode fibre. Lens joints are also used to focus the energy from a light source, and lens joints are more efficient than butt joints in coupling energy from source to fibre. The curves of Figure 9 show what proportion of total energy from a light source is coupled into a fibre using lens and butt joints.

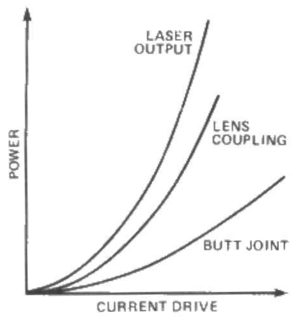
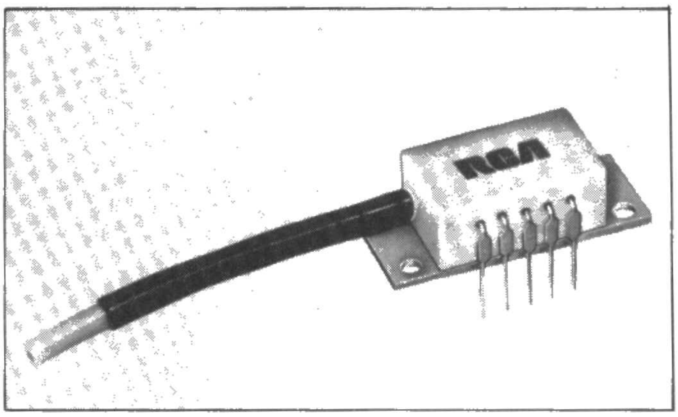


Fig. 9 A comparison of the efficiency of lens and butt joints in optical fibres.



A gallium-aluminium-aresenide laser module operating at 820nm (RCA).

Next month's concluding article will examine the use of fibre optics and lasers in communications and in a variety of other applications from medicine to entertainment.

ETI

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MIDI TO CV CONVERTER

R.A. Penfold describes a converter which allows computers and instruments equipped with a MIDI interface to control synthesisers fitted with gate and CV inputs.

A MIDI interface now seems to be a standard feature on synthesisers and it is also appearing on other instruments such as electronic pianos and portable keyboards. While it undoubtedly provides an easy means of connecting a number of instruments to form a very versatile and powerful system, it cannot be used with synthesisers more than a couple of years old because it is totally incompatible with the old gate/CV control system.

This is a pity, because an old monophonic synthesiser linked to a new polyphonic MIDI-equipped instrument offers interesting possibilities. The monophonic instrument could produce excellent sounds for lead use or perhaps be set to produce percussive sounds, while a MIDI-equipped instrument or a home-computer plus a suitable interface could be used as the system controller.

Driving gate and CV inputs from a MIDI output is quite possible if a suitable converter is included in the system, but ready-made units tend to be quite expensive. This unit provides MIDI to CV conversion with a choice of MIDI channels, but is comparatively inexpensive to build.

Grabbing A Byte

In order to understand how the conversion can be provided, it is first necessary to have a basic understanding of the two systems. The CV system is well known and uses a logarithm scaling of 1V per octave, which is equivalent to 83.3mV per semitone. On/off switching of the notes is controlled via the gate input, which will normally accept standard 5 volt logic levels.

MIDI stands for Musical Instruments Digital Interface, and is a serial interface similar to the standard RS232C and RS423 types. However, there are important differences, one of which is that MIDI is a form of current loop system with an opto-isolator on all inputs. This is primarily to avoid problems with hum loops. It operates at a high baud rate of 31.25k baud, which is higher than any standard RS232C or RS423 baud rate. The format of the word is the popular 1 start bit, 8 data bits, 1 stop bit, and no parity type.

On the software side, note information is sent in groups of three bytes. In order to switch a

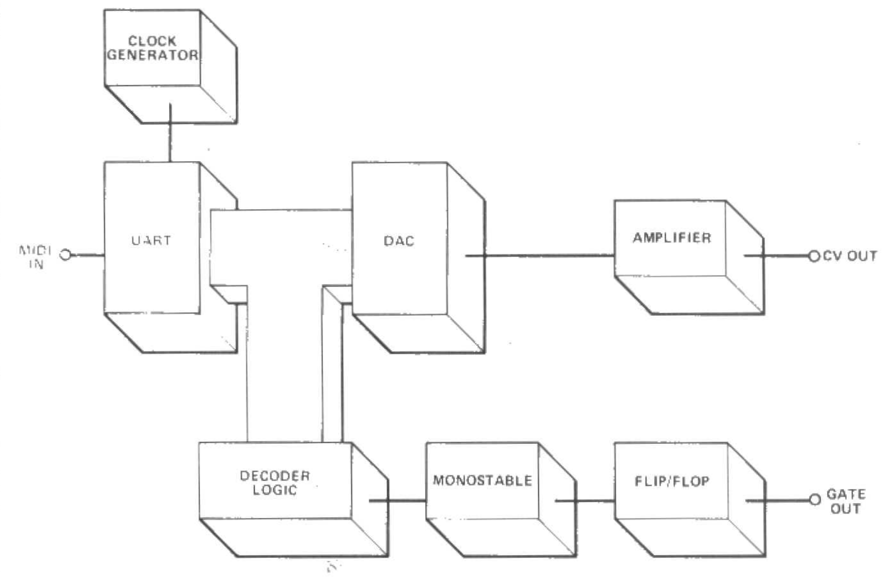


Fig. 1 Block diagram of the MIDI to CV converter.

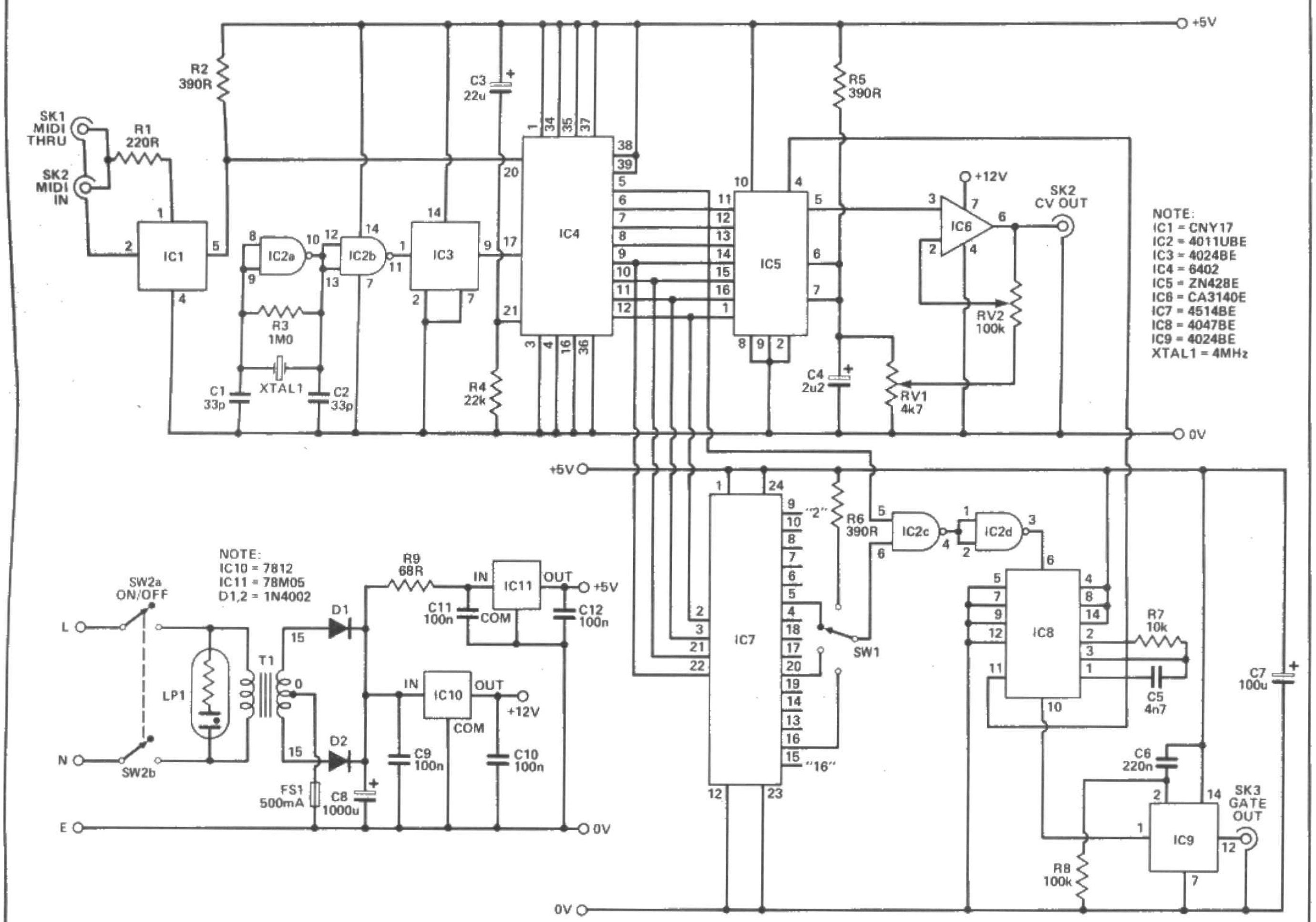


Fig. 2 Complete circuit diagram of the converter.

HOW IT WORKS

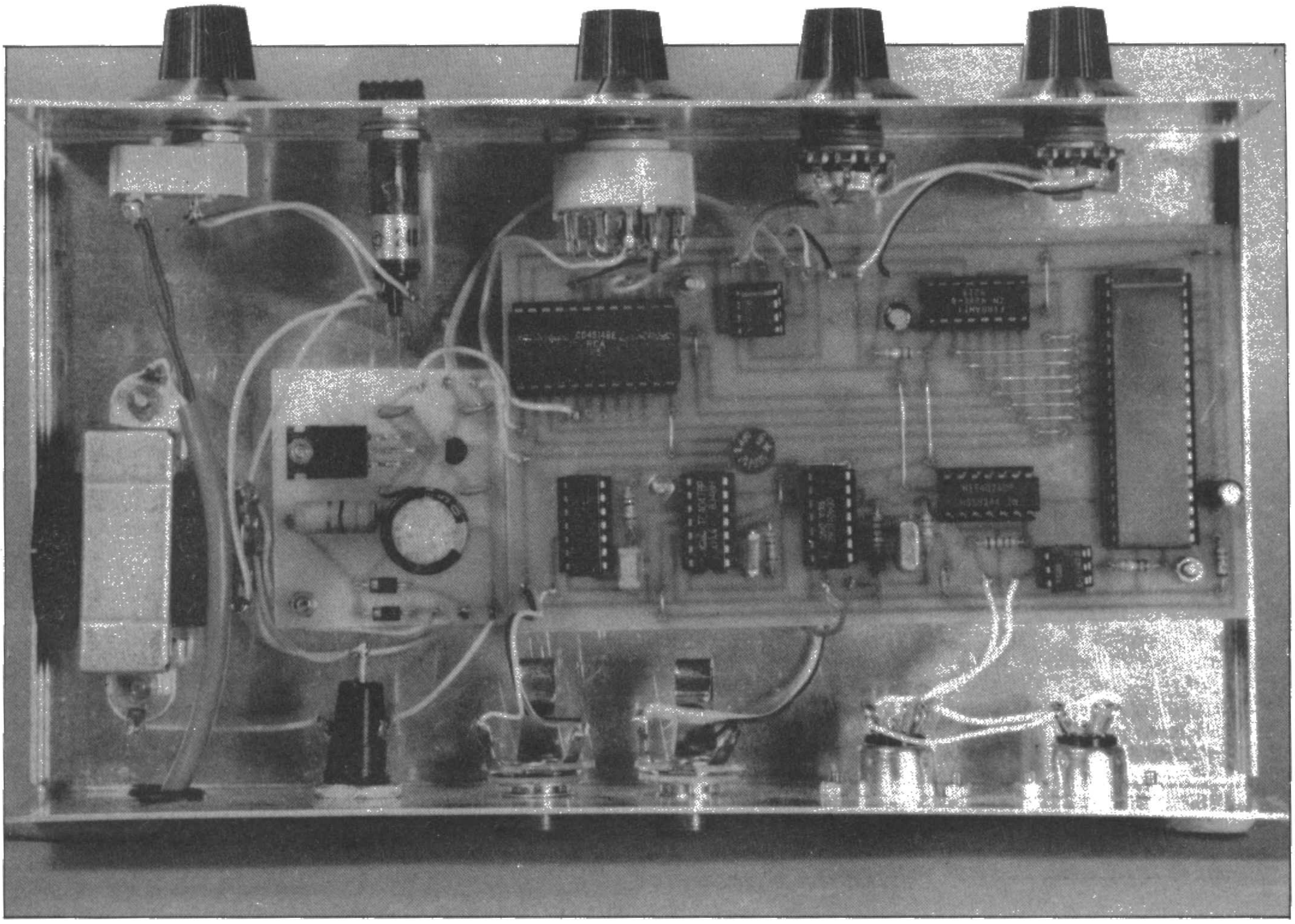
Serial to parallel conversion is provided by the UART, IC4, and pins 35 to 39 are programmed to set up the device for the correct word format. The clock frequency must be 16 times the baud rate which is 500kHz in this case. This is derived from a 4MHz crystal oscillator (IC2a) and three stages of a binary ripple counter (IC3). Because of this fairly high operating frequency, IC2 should be an unbuffered device (4011UBE) rather than a buffered type. IC1 is the opto-isolator at the input, and this is a high speed, high efficiency type. IC5 is the DAC, the popular Ferranti ZN428E device. This has a built-in 2.55 volt reference source which gives output increments of 10mV, but here the LSB is simply tied to ground and the increments are boosted to 20mV. IC6 provides a voltage gain of just over 4 times to boost the increments to the required 83.3mV. RV1 enables the output voltage to be offset downwards by up to 2.55 volts so that the synthesiser will give the correct note and octave for a given MIDI value.

IC7 is a 4 to 16 line decoder and is used to provide 15 outputs which correspond to MIDI channels 2 to 16. The outputs of the UART seem to be briefly reset to zero before taking up a new set of output states, and this renders the channel 1 output of IC7 unuseable. SW1 enables either one of three channels or the 'omni' mode to be selected, where R6 provides a permanent high signal level. IC2 c and IC2d gate the output of SW1 with the MSB of the UART to produce the trigger signal for the monostable (IC8). With the bytes from the UART spaced at least 320us apart, a pulse length of around 200us ensures that the UART has an adequate settling time and that the correct byte is not missed. The not Q output of IC8 drives the latch input of IC5, while the Q output drives flip/flop IC9. C6 and R8 reset IC9 at switch-on so that it commences with the correct (low) output state.

The circuit requires a +5V supply capable of delivering around 100mA, and a 12 or 15 volt supply giving about 4mA. It might be that there is some item of equipment in the system which can provide this, but in most cases a built-in mains power supply will be needed. The circuit shown here is an entirely conventional type based on a couple of monolithic voltage regulators. R9 helps to reduce the dissipation in IC11, and the latter does not generate sufficient heat to merit the use of a heatsink.

BUYLINES

Most of the components are available from the major component retailers, and the only unusual components are the CNY17 opto-isolator and the 6 pin DIL integrated circuit holder. Both of these are stocked by Electrovalue Ltd. T1 can be any mains transformer having either a 15-0-15 volt secondary or twin 15 volt secondaries wired in series and a current rating in the region of 150 to 350mA. IC2 must be a 4011UBE and not a 4011BE. The UBE type is stocked by Maplin. The PCBs will (eventually!) be available from our PCB Service, but see the note in News Digest.



note on the first byte has 1001 in binary (144 in decimal) as the most significant nibble, and a channel value of 0000 to 1111 in binary (0 to 15 in decimal) as the least significant nibble. Things are confused slightly by the general use of MIDI channel numbers from 1 to 16, rather than 0 to 15, and the actual value used to select a channel is therefore one less than the channel number. The second byte is the note value from 1 to 127, and this provides semitone increments with middle C at a value of 60. The third byte contains the velocity value, and this is again in the range 1 to 127 (with 127 representing maximum velocity). Obviously not all instruments are touch senisitive, so a dummy velocity value must be sent in the case of non-touch sensitive instruments in order to maintain compatibility between all MIDI instruments.

The system for switching off a note is basically the same, with three bytes again being used. The only difference is that the header code in the first byte is 1000 in binary (128 in decimal) instead of 1001.

A microprocessor-based system is the obvious basis for a MIDI to CV converter, but would be a fairly complex and costly solution. The system finally devised has a UART (universal asynchronous receiver transmitter) to provide serial to parallel conversion, followed by a DAC (digital to analogue converter) and some simple logic circuitry. The block diagram of Fig. 1 shows the arrangement used.

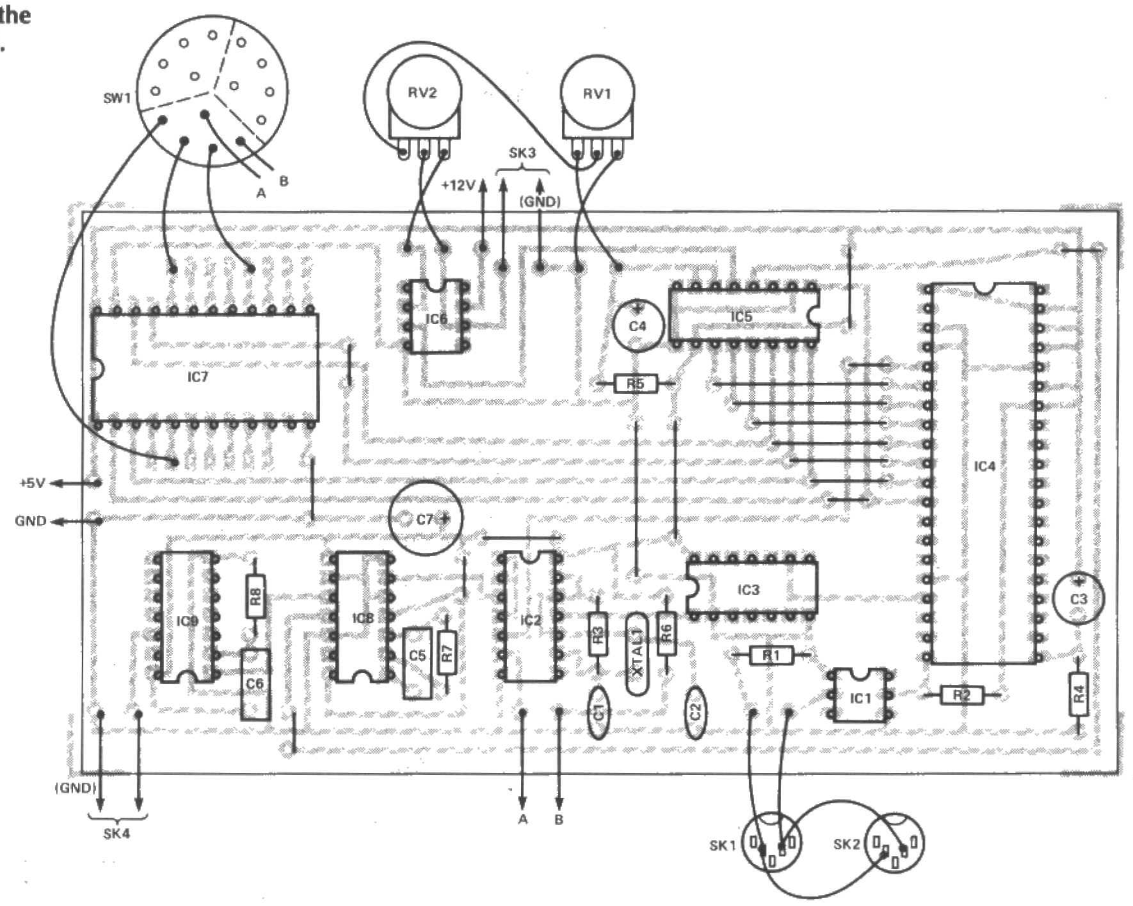
A crystal controlled clock generator sets the UART at the appropriate baud rate and as soon as a fresh byte of data has been received it is transfered to the parallel output. The seven least significant lines are fed to a DAC and an amplifier whch together convert the received note values into corresponding DC output voltages. With the note values held in the middle of three byte groups, some means of selecting only the correct byte in each group must be found.

When operating in the most simple MIDI mode, the 'omni' mode, the unit is triggered by the most significant bit going low when the note value byte is received. This system is viable as the MSB is always high when the note-on or note-off header code is received, but is low when the note and velocity values are received. This high-to-low transition is used to trigger a monostable, and the trailing edge of its output pulse is used to latch data from the UART into the built-in data latches of the DAC. The monostable simply provides a short delay to make sure that the outputs of the UART have had time to stabilise in their new states before the data is latched into the DAC.

The omni mode is of limited practical value, and for most purposes the 'mono' mode is much better. This has each channel of an instrument assigned to a separate MIDI channel. The analogue synthesiser can then be set to play along with one channel of another instrument, or in a computer controlled set-up it could be assigned to an independent channel, effectively giving the system an extra channel. In the mono mode the decoder processes the four least significant bits, so that a note value is only latched into the DAC when the correct channel number is present. The unit can be set to any channel from 2 to 16.

The gate signal is derived from the output of the monostable using a flip-flop divide-by-two

Fig. 3 Component overlay for the main board.



circuit. When a note-on code is detected, the monostable toggles the output of the flip-flop high and sets the output low again when the note-off code is detected. The latches in the DAC are activated by both note-on and note-off codes, but this does not upset the operation of the unit as both codes are followed by the current note value. The CV output will therefore continue to provide a valid output voltage after the gate pulse has ceased, which is essential when the synthesiser's envelope generator is set for a long decay time.

Construction

Apart from the panel mounted components and T1, all the other components are mounted on the printed circuit boards. The power supply board is so simple that it is difficult to envisage any problems here, but the main board needs to be treated with more repect. Start with the link wires and either keep them sufficiently taut to avoid any possibility of short circuits or use insulated sleeving. Add pins at the points where connections to off-board components will be made, then install the passive components. Finally, add the intgrated circuits. As these are mostly MOS devices, fairly expensive types, or both, it is advisable to use holders for all nine of them.

Mechanically the unit is arranged with T1 and the two circuit boards mounted across the middle of the case where they are well clear of the panel mounted components. The boards must be mounted using stand-offs or with spacers over the mounting bolt so that the undersides of the boards are held well clear of the case. Soldertags fitted on the mounting bolts of T1 provide chassis connection points. The controls and LP1 are mounted on the front panel with the sockets and the fuseholder fitted on the rear panel.

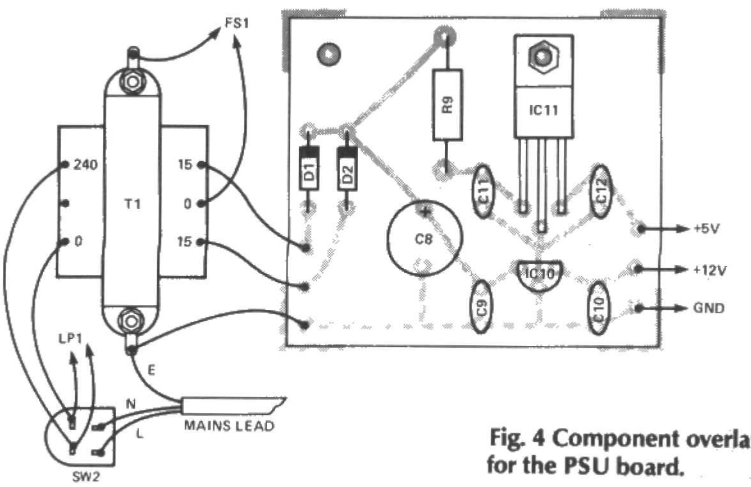


Fig. 4 Component overlay for the PSU board.

PARTS LIST

RESISTORS (all ¼ W 5% unless stated)	
R1	220R
R2, 5, 6	390R
R3	1M0
R4	22k
R7	10k
R8	100k
R9	68R 1W
RV1	4k7 linear potentiometer
RV2	100k linear potentiometer
CAPACITORS	
C1, 2	33p ceramic plate
C3	22u 16V radial electrolytic
C4	2u2 63V radial electrolytic
C5	4n7 polyester layer
C6	220n polyester layer
C7	100u 10V radial electrolytic
C8	1000u 25V radial electrolytic
C9, 10, 11, 12	100n ceramic
SEMICONDUCTORS	
IC1	CNY17 opto-isolator
IC2	4011UBE
IC3, 9	4024BE
IC4	6402
IC5	ZN428E
IC6	CA3140E
IC7	4514BE
IC8	4047BE
IC10	78L12
IC11	78M05
D1, 2	1N4002
MISCELLANEOUS	
SW1	4-way 3-pole rotary switch
SW2	rotary mains switch
LP1	panel-mounting neon with integral resistor
FS1	20mm 500mA quick-blow fuse and panel-mounting holder
T1	15-0-15 volt mains transformer, 150 to 330mA secondary current
SK1, 2	5-way DIN sockets (180 degree)
SK2, 3	mono ¼" jack sockets
X1	4MHz HC-18/U crystal

PCBs; 230 x 133 x 63mm metal instrument case; IC sockets, 1 off 40 pin DIL, 1 off 24 pin DIL, 1 off 16 pin DIL, 4 off 14 pin DIL, 1 off 8 pin DIL, 1 off 6 pin DIL; four control knobs; mains lead, solder-tags, fixings, case feet, PCB pillars, etc.

The hole for the mains lead is drilled in the rear panel and should be fitted with a grommet to protect the cable. The case must be connected to the mains earth lead for safety reasons.

There is only a limited amount of hard-wiring needed to complete the unit and none of it should give rise to any real problems, but take due care when wiring up the power supply. SW1 is wired to the board to select the three MIDI channels you require, or a switch with more than four ways can be used if you require a greater number of channels.

Testing

The way in which the converter is connected into the MIDI system depends on the particular set up concerned, and can range from the simple two synthesiser set-up of Figure 4(a) to a more sophisticated arrangement such as that shown in Figure 4(b). Five way DIN leads of up to 15 metres long are used for all interconnections, but if you are making up your own leads note that only pins 4 and 5 are used.

Initial testing is most easily carried out with the unit connected to a synthesiser as in Figure 5(a) and set to the omni mode. With RV1 set fully counterclockwise and RV2 at a roughly mid setting, the CV output voltage should vary in sympathy with the note played on the MIDI synthesiser, and the gate output should go positive while a key is depressed. Adjusting RV1 and RV2 is a matter of first setting RV2 for the correct pitch with the top note of the MIDI synthesiser's keyboard operated, then adjusting RV1 for the correct pitch with the lowest key operated. This procedure should be repeated a few times until good tracking is obtained over the full compass. By advancing RV1 in a clockwise direction the pitch range can be moved down one or two octaves, but adjustment of RV1 will probably necessitate slight readjustment of RV2 as well. It is probably best to adjust RV1 to shift the range down by a single octave, but this really depends on the precise voltage-to-pitch relationship of your synthesiser.

Expansion

If several gate and CV outputs are required, one way of achieving this would be to use a separate unit for each channel. A more economic solution would be to use a common UART and decoder for all channels, with these driving separate gates, monostables, DACs, and flip/flops. If more than two DACs are to be driven, the outputs of IC4 would probably need to be buffered.

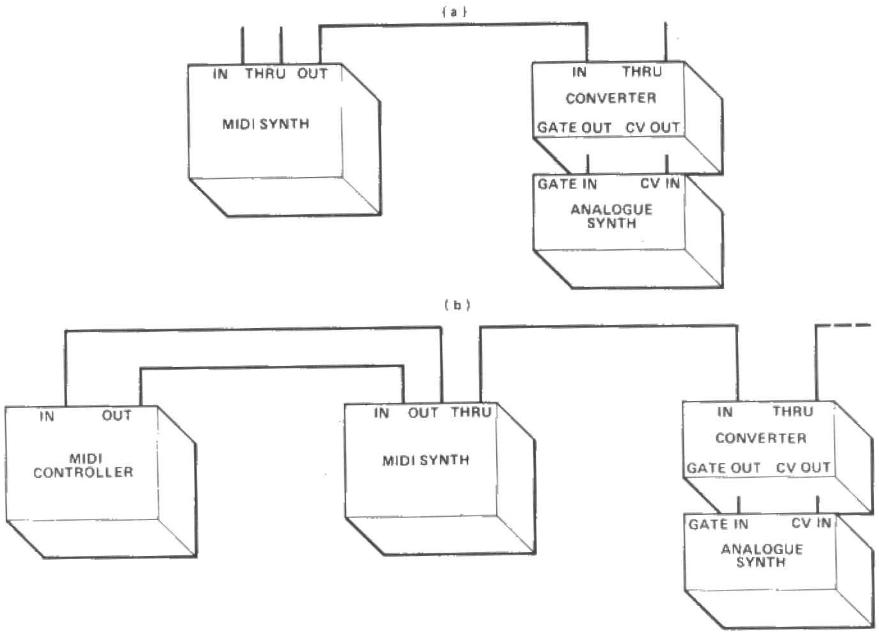
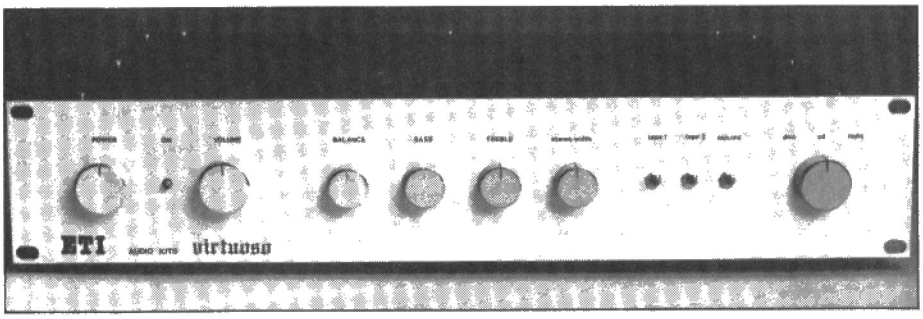


Fig. 5 Possible MIDI set-ups using the converter.

UPGRADEABLE AMPLIFIER

Graham Nalty introduces his latest design with some thought-provoking comments on hi-fi amplifier design.

The amplifier which forms the subject of this series of articles has been designed so that it will be very easy to build. In its simplest form it offers good sound quality at a very reasonable cost, but once built, it can be improved in stages to offer even higher sound quality. The improvements include substituting componenets of higher quality, using better cables for internal wiring and adding separate power supply electronics for different parts of the circuit. The final result is an amplifier of outstanding performance, yet all the modifications required are quite straightforward and are easy to implement and test.



Power Supply

No part of an amplifier has a greater effect on the overall sound quality than the power supply yet comparatively little has been written about PSUs compared with the dozens of different amplification stage circuits published in various magazines.

The most effective way of upgrading a preamp or power amp is to replace the mains transformer with a larger one. In a preamp which may draw only tens of milliamps, a transformer with a secondary capable of delivering several amps is very cost effective in terms of sound quality. The problem in using such a large transformer is that it makes it difficult to eliminate hum from low level circuitry, particularly if you want to use a switch on the front panel to select between moving coil and moving magnet inputs. A steel case would be needed as aluminium cases give rise to screening problems. Of course, you can use a battery power supply, eliminating the hum problem and giving excellent sound quality. It is a practical alternative, especially with rechargeable Ni-cads, but it is also quite expensive.

One of the prime requirements for a stereo amplifier is good stereo imaging. Most commercial amplifiers use one supply to power both left and right channels. The use of separate supplies for each channel of an amplifier will make a big overall improvement. This can easily be verified if you have two samples of a low priced amplifier. Whatever source you use (disc is best for this demonstration) connect one

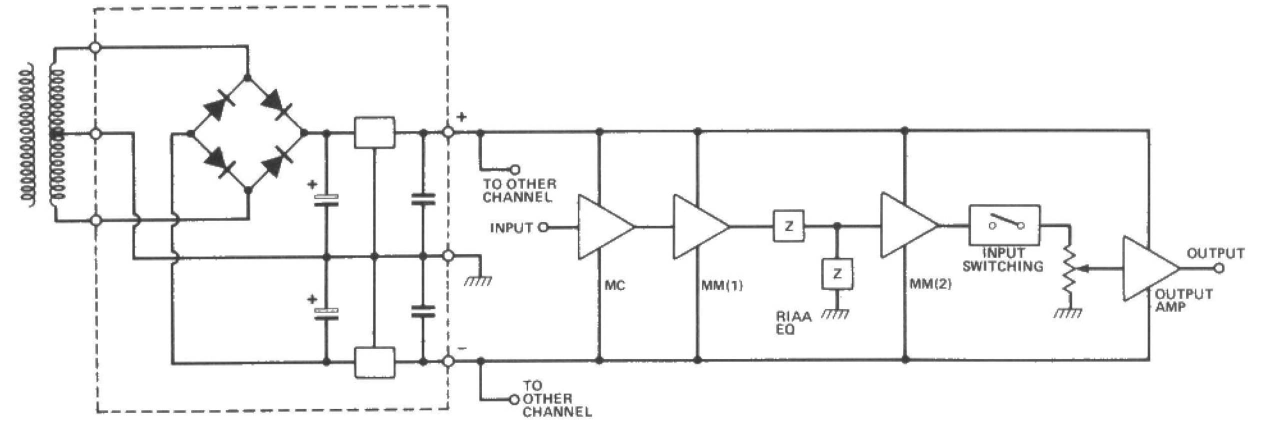


Fig. 1 Preamplifier power supply arrangements in their simplest form. . . . .

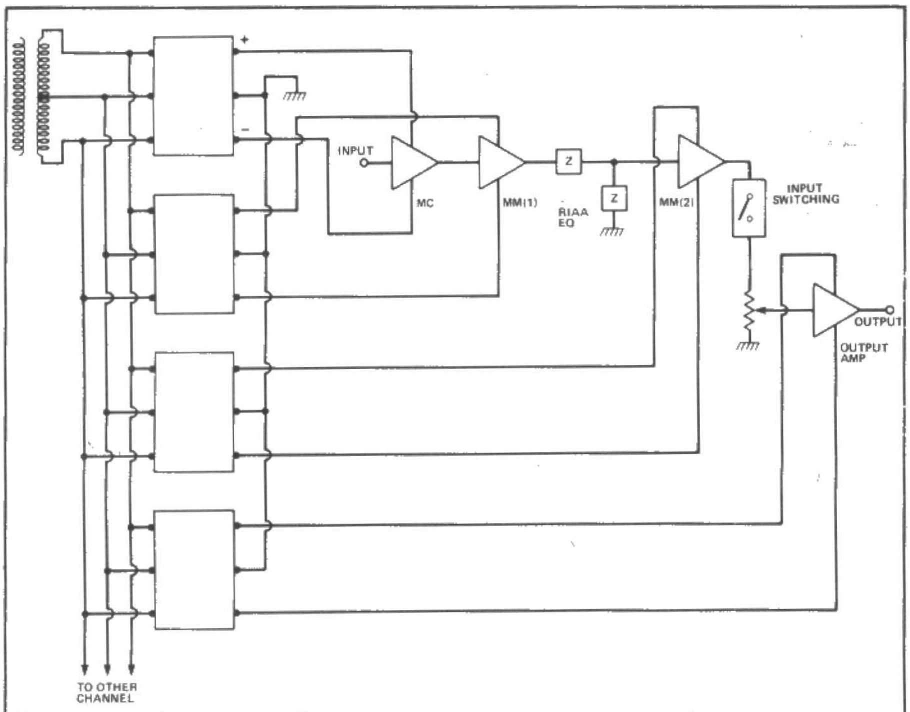


Fig. 2 . . . . and after upgrading.

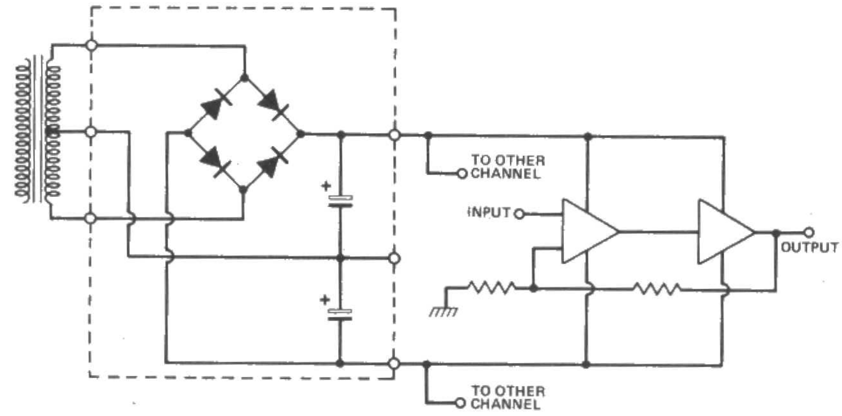


Fig. 3 Power amplifier supply arrangements in their simplest form. . . . .

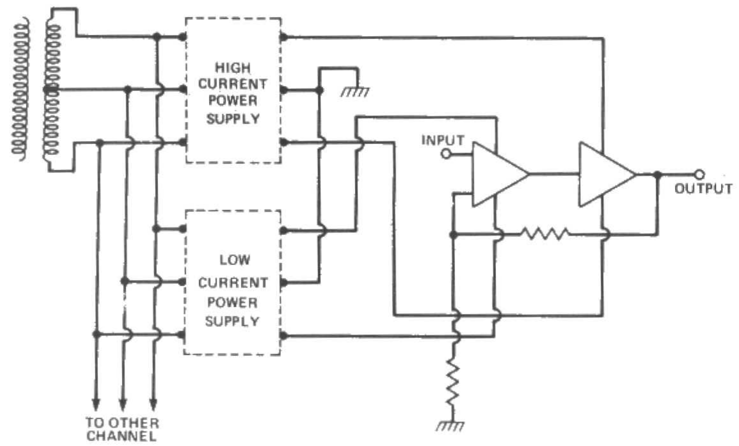


Fig. 4 . . . and again, after upgrading.

amplifier from source to speakers for one channel and the second amplifier for the other channel. You should notice a big improvement in clarity and stereo imagery compared with using one amplifier in stereo. This is probably the main reason why some people have a preference for bridged power amplifiers.

In practical terms, the use of two mains transformers is not as cost effective as doubling the size of the transformer. The cost of two transformers rated at X VA is twice the cost of one whereas a single transformer with a rating of 2X VA may only cost about 25% more than a single one. Additionally, a single large transformer will give a tighter, cleaner sound if not quite as good imagery as two smaller ones. Most of our perception of stereo image location is via high frequency sounds, and the use of separate rectifiers and smoothing capacitors for each channel affords greater separation at high frequencies than low frequencies. This renders the additional advantage of separate transformers of small benefit by comparison.

In its simplest form this amplifier uses a single power supply. It can be improved step by step, first by adding a second rectifier, capacitor and regulator set, then by providing separate supply electronics for the disc circuits and output circuits (that is, those which come after the volume control). The final level of improvement is to use separate supplies for each stage of amplification in the preamp and separate electronics for the high and low current parts of the power amplifier. Figures 1 and 3 show the power supplies for preamp and power amp in the simplest form and Figs. 2 and 4 show the final versions after all upgrading.

Components

A good amplifier needs good components, and one feature of this amplifier project is that improvements in sound quality can be made simply by changing components.

If you are a relative newcomer to electronics as a hobby, you may be reluctant to spend a lot of money on the project because you are not certain how it will turn out. In this case, there is nothing to stop you using standard components such as carbon resistors, electrolytic capacitors

Type	Brand	Range	Tolerance	Temperature Coefficient PPM/°C	Voltage Coefficient PPM/V	Noise µV/V
Carbon	Piher PR50	1R0-1M0	5%-20%	180-500	5	0.1-1
		1M0-10M	5%-20%	500-800	5	
Metal Oxide	Electrosil TR5	10R-1M0	2%	200		0.2
Metal Film	Neohm LR1	10R-1M0	1%	50	10	0.05
	Welwyn MFR4	10R-1M0	1%	50		
Semi Precision Metal Film	Holco H8	10R-1M0	0.5%	50	5	0.2
Precision Metal Film	Holco H8	100R-250K	0.1%	15	5	0.2
	Resolute RC 65	200R-1M0	0.05%-1%	5-100	negligible	0.1
Ultra Precision Metal Film	VTM MAR 7	10R-3M0	0.01%-0.5%	2-15		
	Welwyn 48XX	3R5-300K	0.01%-1%	1	zero	not measurable

Table 1 A comparison of the specifications of various resistor types.

Type	Brand	Range	Voltage	Power Factor at	Frequency
Aluminium	Sprague 509D	10u-2200u	16	0.16	120
		10u-2200u	25	0.14	120
		4.7u-1000u	40	0.12	120
		1u0-220u	63	0.09	120
		0.47u-100u	100	0.08	120
Tantalum	Sprague 499D	100u-220u	6.3-35	0.1	100
		10u-47u		0.08	100
		1.5u-6.8u		0.06	100
		100n-10u		0.04	100
Polyester	LCR MKT	10n-10u	160-630	0.01	1000
Polycarbonate	Suflex CPC	10n-4.7u	63-250	0.003	1000
		6.8u-10u		0.005	1000
Polypropylene	LCR KP/DMT	150n-1.5u	160-400	0.0005	1000
Polystyrene	Suflex EXF	200p-250n	30-160	0.0003	1000

Table 2 A comparison of the specifications of various types of capacitor.

and low gain transistors, and the amplifier will still work and will not sound bad.

But if you share my view that a job that is worth doing is worth doing well, you will want to start with components which are of good quality but reasonably priced. For each part of the project, a 'designer approved' economy kit of components will be specified. At the same time higher quality components will be specified so that you can upgrade or start at an intermediate version.

Close tolerance metal film resistors are now available at low cost and I have specified these for all parts of the circuit handling the audio signal. Researchers who have carried out listening tests report that metal film resistors offer a detectable improvement in sound over metal oxide types which in turn are better than carbon types. Table 1 shows the specifications for a selection of different types of resistors. There are a number of manufacturers of metal film resistors of comparable specification, and although differences have been reported between different brands (Ref 1) I do not propose to identify or specify any preferences.

There is also evidence that semi-precision and precision types offer further improvements in sound quality over 'general purpose' metal film types (Ref 1). At this point things become expensive as the best precision resistors will cost several pounds each in small quantities. If you are going to use precision types and wish to be as economical as possible, a sensible rule to apply is to use a higher grade for loading resistors and feedback resistors and a lower grade for resistors whose distortions can be reduced by negative feedback.

A great deal has been written about the influence of capacitors on audio sound quality. The International Audio Review (Ref 2) has reported on capacitors in great detail. Leading authorities believe that the main cause of audible distortion in capacitors is dielectric absorption and have developed methods to measure it. (Refs 3, 4). My own experiences back up the work of these and other researchers, and I would accept as a general rule a correlation between capacitor types with low dielectric loss and good sound quality. Mechanical considerations must also affect the sound quality of capacitors and this includes the internal construction and the firmness with which the capacitor can be attached to the PCB. Table 2 shows some typical characteristics of different capacitor types.

In keeping with my policy of using good quality components, polyester capacitors will be specified for all functions except the main rectifier smoothing, where a polyester capacitor of smaller value will be placed in parallel with the electrolytics. Upgrading of the capacitors will be by changing the polyester capacitors to polycarbonate and then to polypropylene, and by placing additional low value polystyrene types in parallel with all capacitors over 100n.

There is not much scope for upgrading semiconductors, other than using ultra low noise types in the moving coil input.

Wires And Cables

A wire is an amplifier without gain. This comment may be a parody on a well-known phrase, but all cables do change the sound quality of the signal passing through them. Some change the balance between different frequency ranges whilst others maintain the frequency balance but reduce the clarity. There are no perfect cables, but some of the more expensive types do give a better sound quality.

If this is your first amplifier project you may be quite happy to use inexpensive cables and you will still end up with a good amplifier. At a later date you can change to more expensive cable types and by experimenting make a really worthwhile improvement to the sound quality.

When upgrading, it is important to change the cables carrying power supplies as well as those carrying the audio signal.

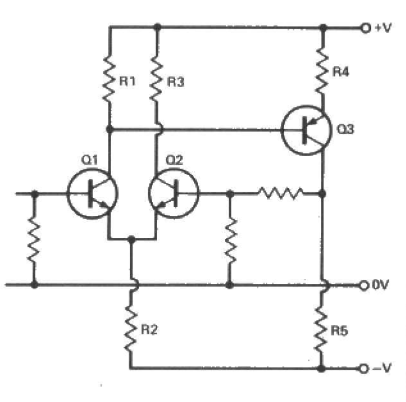


Fig. 5 Basic active circuitry of the preamplifier.

Circuitry

The requirement for the active circuitry is that it should be easy to build and test but should be capable of outstanding sound quality at the end of the upgrading process. A preamp could be built without negative feedback, and would be easier to test since feedback loops make it difficult to find the location of a fault. But we have to use negative feedback in the power amplifier, and it is a good idea to use a circuit in the preamp which will be fairly similar to that used in the power amp.

The discrete op-amp circuit of Fig. 5 is ideal for the purpose. Readers who have seen Stan Curtis's excellent preamp design in July 1981 using a seven transistor op-amp may be disappointed at first, but I can assure them that if they follow the upgrading procedures they will change their minds. One of the upgrading procedures is to replace resistors R2 and R5 with FET constant current diodes which give much greater power supply ripple rejection than one-transistor or two-transistor current sources. Another advantage of the FET is that in the case of a fault in the circuit, it can be checked simply be replacing it with a resistor of the correct value.

Resistors R3 and R4 are included solely for the purpose of enabling the collector currents of Q2 and Q3 to be measured. R4 reduces the amount of negative feedback in the circuit. Some designers like to use circuits with large amounts of negative feedback whilst others prefer a modest amount of feedback. Whilst varying the amount of feedback will change the sound a bit, the exact amount of feedback is of secondary importance unless you go to extremes. And knowing the limits of the amount you can use is one of the secrets of good amplifier design.

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3. Audio Amateur. 4/1980. Dielectric Absorption in Capacitors. by R. Marsh.

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Next month's article will cover the construction of the moving coil input stage in both its basic and upgraded forms.

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19×3.5	17×3×12	25.50	30.50
19×5.25	17×5×12	27.50	32.50
19×5.75	17×5.5×12	28.50	33.50
* 17×2.5	15.5×2×9	16.50	20.50
* 17×3.5	15.5×3×9	17.00	—
* 19×3.0	17×2.5×10	—	20.50
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THE ETI TROGLOGRAPH

Readers of last month's article will know that Mike Bedford has the low-down. As he describes the Troglograph design and construction from a puddle in the middle of Gaping Gill, we ask if he's not caving but drowning ...?

The design for a VLF transceiver took some weeks of theoretical and practical work. Several prototypes were developed and each one was tested in the field. The starting point for the whole process was to break the system up into its major component parts — aerial, transmitter and receiver. A single aerial is used for both transmitter and receiver sections of each transceiver, and the designer's major concern, in the first instance, was portability.

The Aerial

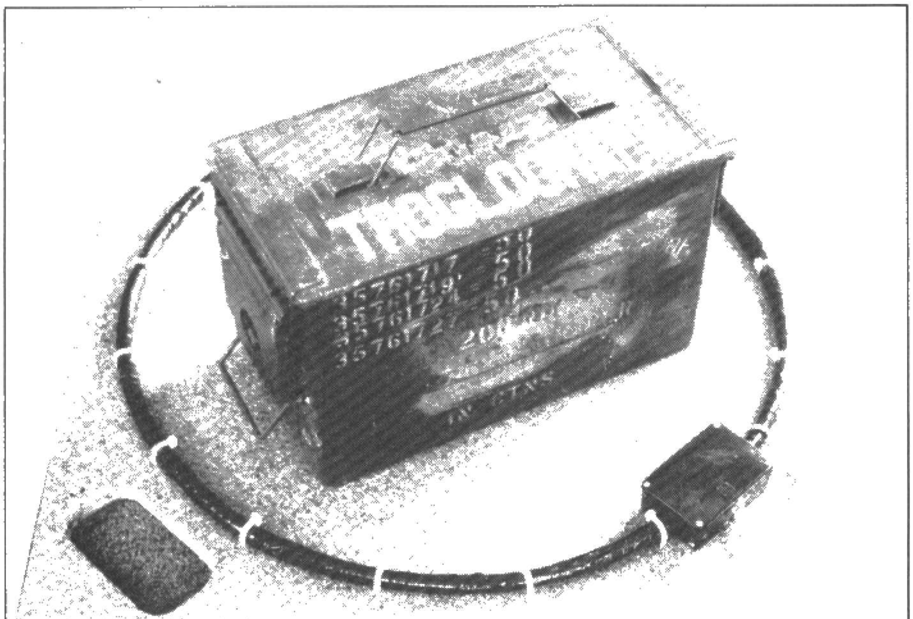
Two main types of aerial are used in inductive communication. The first is the loop antenna and the second is a pair of widely spaced ground rods which, in effect, cause a large area of the earth to act as a current carrying loop. The latter aerial is also used for earth mode communication — closely related to inductive communication.

Only the loop aerial was considered for the Troglograph, since portability was a prime concern — especially in potentially small cave passages — and the ability to transmit a predictable field and sense its angle and direction is crucial to radio location.

The formula governing the field strength transmitted by a current carrying coil is

$$H = INA$$

where I is the loop current, N is the number of turns on the loop and A is its area. Clearly a large diameter loop with a large coil area is a comparatively easy way to maximize field strength. Because the aerial had to be carried down tight passages a diameter of only 19 inches was picked. It would be interesting to experiment with large diameter loops for the surface station. These would give greater range when direction finding is not required.



The Troglograph

Having fixed the diameter, the number of turns and the wire gauge (which affects resistance and hence current) need to be chosen. For transmission, there is no advantage in increasing the number of turns to a coil without also increasing wire diameter. If the number of turns is doubled, resistance will also double and current will halve — which cancels out the effect of increasing the number of turns. The wire gauge can be increased to restore the effect, but you will have four times the weight of copper wire. Quite apart from cost considerations, weight increase is something which should be avoided in portable equipment.

All this is particularly relevant when you remember that the magnetic field decays with the cube of the distance, which means that to double transmitter range, an eightfold increase in field strength is required needing 32 times the weight of copper wire! The conclusion is that, for a given wire gauge, there is no advantage in increasing the number of turns beyond those required to give a sufficiently high resistance to keep the final amplifier current within specification.

Since the received signal strength is proportional to the number of turns on the receiving aerial and since there is a clear advantage in using the same aerial for transmission and reception, we need to compromise. The actual specification for the Troglograph chosen was 120 turns of 22SWG enamelled copper wire. If a source of inexpensive copper wire is available, the constructor could try 240 turns of 18SWG, which would give about 1.6 times the range if used for both transmitter and receiver.

The specified coil has a DC resistance of 8 ohms. Its inductance of 18mH will give a reactance of 384ohms at the chosen operating frequency. This inductance needs to be tuned out in a series tuned circuit in order to get the impedance down to 8 ohms and achieve the required current. For reception, on the other hand, the coil should be configured in a parallel tuned circuit resonant at the operating frequency. This will maximize the impedance and consequently the voltage induced in the coil by the magnetic field.

The Transmitter

Research suggests that frequencies in the 3kHz region are quite suitable for CW and direction finding, being low enough to be largely unaffected by passage through limestone and high enough to be clear of the stronger harmonics of 50Hz power lines which can cause significant interference even in remote areas. Since 32.768 kHz crystals, as used in digital watch circuits, are cheap and easy to get, the actual frequency chosen was 3.2768 kHz, which can be generated easily from this crystal by use of a TTL divide-by-ten chip.

The transmitter requirements are therefore a 32.768kHz oscillator, a decade divider, a power amplifier and a keying circuit. The keying circuit is a switchable option to a morse key for use in direction finding. This automatically keys the transmitter on and off, making reception easier than it would be with a steady carrier at low signal strengths.

The only other decision which needs to be made about the transmitter is its power. Since the aerial coil resistance is fixed, the transmitter characteristic which affects the coil current is the applied voltage. Increasing coil current by increasing the voltage has the effect of increasing power dissipation by the square of the voltage increase. In portable equipment, power requirements have to be kept as low as possible. To take the example of doubling the range again, the current requires an eight fold increase and the power would have to increase by 64 times. Once again a compromise between radiated field and the price and portability of the equipment has to be reached. A 24V supply — easily provided by a pair of 12V, 2.6AH lead acid batteries — was selected.

Since digital techniques are used for signal generation, square waves will be fed to the aerial. In normal radio transmitters this would be guarded against to avoid trouble with the harmonics which would be generated. This is not a major problem in this design, because the aerial is a medium Q turned circuit which ensures that the harmonics will be very much attenuated with respect to the fundamental. When the inverse cube law is considered, it will be realised that any surviving harmonics will only travel a very short distance before becoming quite undetectable.

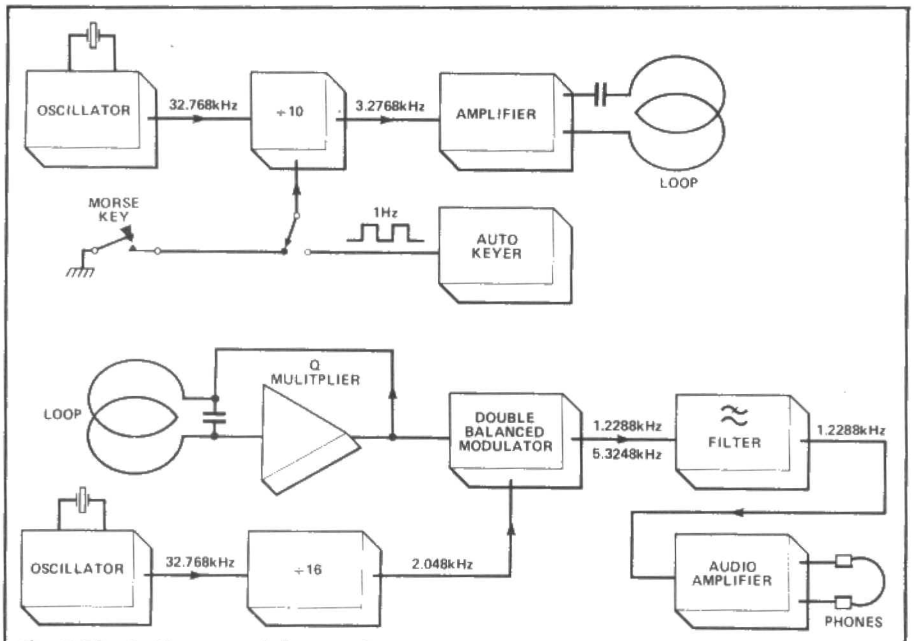


Fig. 5 Block diagram of the receiver.

The Receiver

In its simplest form, the receiver may consist of a tuned aerial connected to an audio amplifier driving a pair of headphones. Significantly more gain can be achieved by connecting the aerial in a Q-multiplier configuration which, in effect, cancels out the resistance of the coil and increases sensitivity and selectivity.

It is quite impossible to use magnetic headphones in such a configuration. These generate their own magnetic field which would feed back into the aerial and cause self oscillation. Even if crystal headphones are used, there is still a limit to the amount of amplification which can be achieved before the magnetic field radiated from the circuit wiring causes feedback.

The solution to the problem is to use a technique similar to that used in superheterodyne receivers (Fig. 5). A local oscillator is used to translate the frequency of the received signal so that it can be amplified without the fear of instability. In addition, an active bandpass filter is included after the frequency conversion stage to reduce interference.

Since the Troglograph is a transceiver, there is an advantage in sharing portions of the circuit between the receiver and the transmitter to reduce overall circuit complexity. This explains the choice of 2.048kHz as the local oscillator frequency, since it can be generated from the transmitter's 32.768kHz oscillator by use of a divide-by-16 chip. The resultant received frequency of 1.2288kHz (3.2768 minus 2.048) is a quite acceptable audio tone.

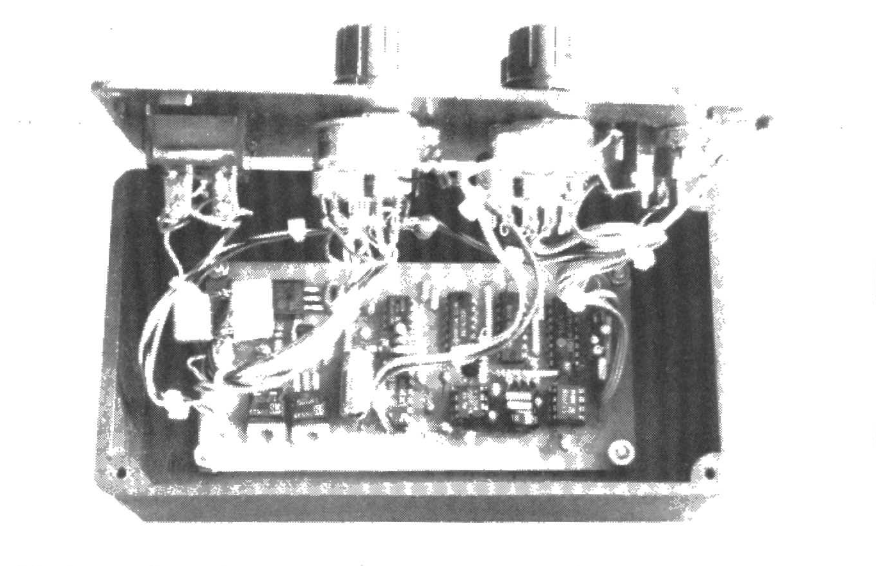
Construction

The construction of the main circuit board is quite straightforward. A PCB should be used to give a more rugged construction than obtainable with, say, Veroboard. In the interests of a good, solid construction — which is very important for a piece of portable equipment likely to be subjected to rough conditions underground — sockets should not be used for the ICs.

Those who take this comment with a pinch of salt should note that it is not uncommon even for 28-pin devices to jump straight out of their sockets when a PCB is dropped three feet onto a hard floor. The lack of sockets means that some care needs to be taken in soldering the ICs, especially IC4 which is a CMOS device requiring the usual precautions.

The PCB can be conveniently housed in an ABS plastic box, mounting the various switches, sockets and potentiometers in the top as appropriate. A strong rocker switch should be used for the power switch (SW3), these being less prone to accidental switching when subjected to mechanical shock than toggle or slider switches. Note that R23 is wired directly on to switch SW2 and is not mounted on the PCB.

Only two aspects of the circuit require setting up. The first of these is the active filter in the receiver, the centre frequency of which is controlled by RV2. This can be easily adjusted once two rigs have been built. RV2 is simply tuned for maximum received signal strength on one rig while the other is transmitting. The other part of the circuit which requires specific setting-up is the selection of C19, the capacitor used to tune the loop aerial to resonance. The equation used to calculate the value of this capacitor is:


Inside the Troglograph

$$C = 1/4\pi^2 Lf^2$$

where L is the inductance of the coil in Henrys and f is the frequency in Hertz — 3276.8. Although the inductance should be accurately measured if at all possible and the value for C

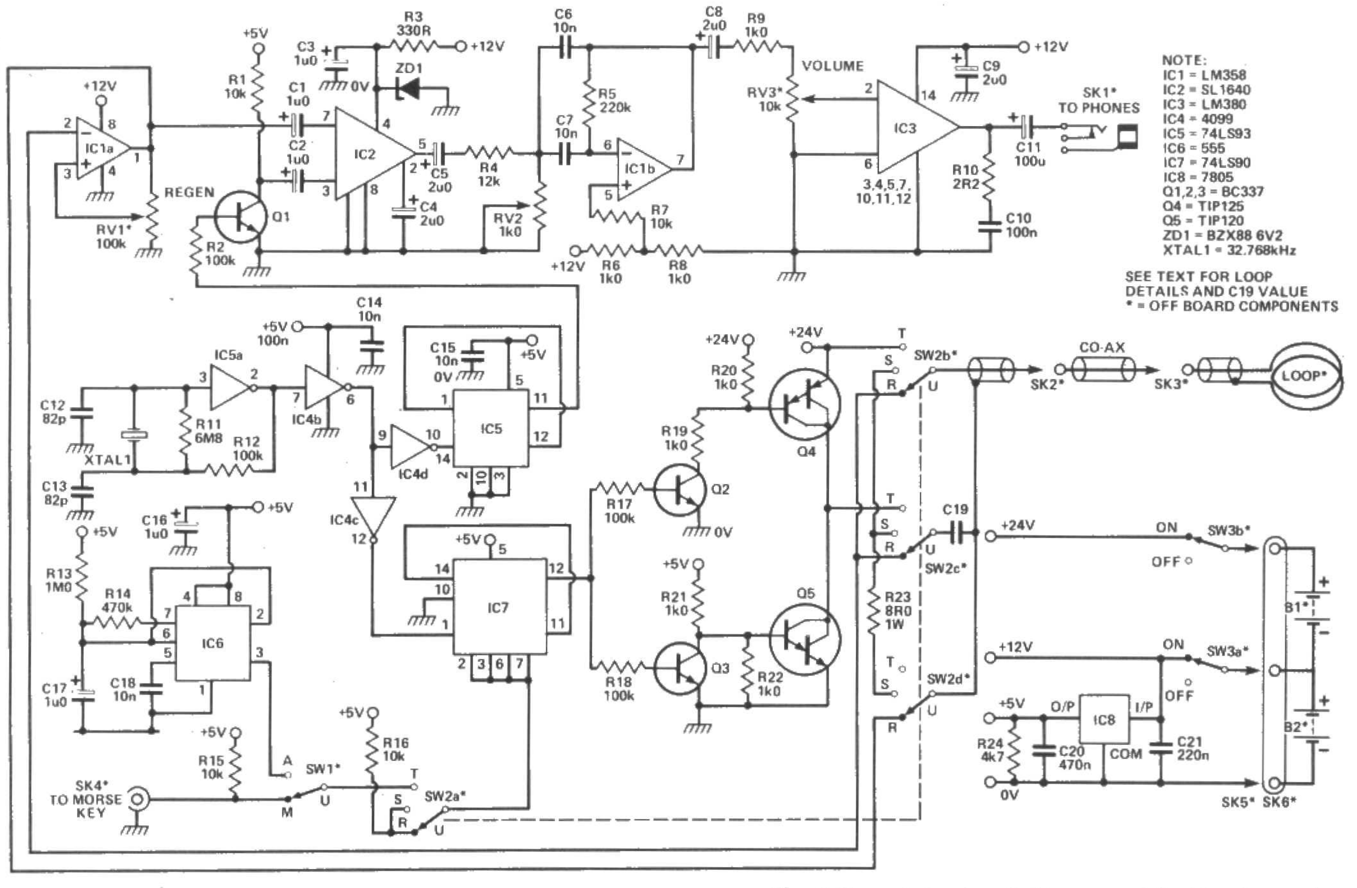


Fig. 6 Complete circuit diagram of the Troglograph.

calculated, not everyone will have inductance measuring facilities. So long as the coil is wound as described and the number of turns carefully counted to avoid mistakes, the inductance will be about 18.6mH — making a capacitor value of 126.5nF.

This capacitor will need to be made up from a number of smaller capacitors and these *will have* to be measured in order to obtain the required accuracy. This is important since most capacitors have a tolerance of only 20% or 10% at the best, and if C19 is wrong by more than 4nF, the transmitted current will drop by half. A space for this capacitor has been artworked on the PCB. Since it will have to be made up from a number of capacitors, it may be found easier in terms of space to wire it between SW2 and SK2 on the underside of the top cover.

The winding up of the loop aerial is a tedious task and is probably better undertaken 50 turns or so at a time! The following method was found quite effective by the author:

Take a piece of chipboard and mark on the surface a 19" diameter circle. Now take sixteen 2" nails and make a right-angled bend in each using a vice and hammer. These nails should then be hammered into the board, spaced evenly around the circumference of the circle with the nail heads pointing away from the centre. One end of the copper wire should then be fixed to the board and the coil wound in the U-shaped channel formed between the two edges of the nails and the surface of the boards.

Once the required number of turns have been wound, the coil can be secured by wrapping insulating tape around the windings at a number of points around the circumference. It is now safe to remove the loop from the board. A co-ax socket should then be soldered to the two free end of the copper wire after which the whole assembly should be made thoroughly watertight by the use of copious quantities of insulating tape and varnish.

The co-ax socket is mounted in a very small ABS plastic box which is subsequently filled with plastic padding to prevent the ingress of water. A dummy plug filled with plastic padding and tethered to the loop should be provided for transit to avoid mud and water making its way into the socket.

For a more rugged construction, the completed loop could be attached to a square of well varnished chipboard but, if ease of portability is more important and radio location is not to be used, the loop could be carried loose. For radio location, the cave loop will require a spirit level attaching to the board to ensure that it has been positioned precisely horizontally. The surface loop, on the other hand, would need an accurate inclinometer to measure vertical angles of null.

It just remains to provide a robust means of carrying the

HOW IT WORKS

IC4a and b are configured as a standard crystal oscillator circuit providing the 32.768kHz master clock signal. This is buffered by IC4c and d which feed the two LS TTL dividers. This double buffering is used since each of the 4049's six gates will only drive one TTL load, despite the IC being intended for interfacing CMOS to TTL.

IC7, a 74LS90 decade counter, derives the transmit frequency of 3.2768kHz from the master clock. This IC is connected in bi-binary mode (divide-by-five followed by divide-by-two) producing a symmetrical divide-by-ten count on the Q_A output, pin 12. The function of the 74LS90 divider is controlled by the logic level on pins 2, 3, 6 and 7. If a logic high is applied to all these pins, the output on pin 12 will go to a constant high. A logic low will enable the chip's normal divide function. This gives a simple means of keying the transmitter.

With switch SW1 in the M position, the logic level at socket SK4 is connected to these control inputs, allowing a morse key to be used. With the switch in the A position, the output of IC6, an NE555 timer, controls the divider chip producing tone bursts at a fixed rate. The NE555 is connected in an astable configuration, giving a 1Hz output with an equal mark-to-space ratio and providing the automatic keying needed for direction finding.

The 3.2768kHz signal is passed from IC7 to Q2 and Q3 which drive the final output stage consisting of the darlington transistors Q4 (PNP) and Q5 (NPN). In the transmit position, switch SW2 connects the loop and C19 in the required series tuned circuit configuration.

For reception, IC1a — an LM358 op-amp — is connected as a Q-multiplier with the aerial in the negative feedback loop and a potentiometer, RV1, in the positive feedback loop. This potentiometer controls the degree of feedback which in effect cancels out the resistance of the loop, increasing the sentivitity and selectivity. If the control is advanced too far, the amplifier will become unstable and oscillate at the resonant frequency. With SW2 in the receive position, the loop and C19 will be connected as a parallel tuned circuit.

The output of this first stage is fed to the input of IC2, an SL1640 double balanced mixer. A DBM is a device which takes two frequencies and generates the mix products while attenuating the input frequencies so that they do not appear at the output. The result of mixing two frequencies f1 and f2 is the sum f1+f2 and the difference f1−f2. In this circuit the two input frequencies are provided by the received signal (3.2768kHz) and by the master oscillator via IC5, a 74LS93 divide-by-16 device.

The 74LS93 is a similar device to the 75LS90, but has a four-stage binary counter and gives an output frequency of 32.768/16 = 2.048kHz. The SL1640 presents too great a load to be driven directly by an LS TTL output. So Q1 is used to give a higher current driving capability. The value of R1 was chosen so that the voltage output would be 200mV as required by the SL1640.

The DBM outputs both a sum and a difference frequency — 5.3248kHz and 1.2288kHz in this case. 1.2288kHz is quite an acceptable audio tone. IC1b is configured as a Sallen-Key bandpass filter with a medium Q. The resonant frequency of the filter is fine tuned by RV2 to 1.2288kHz.

These stages of the receiver circuit are designed to attentuate input siganals of frequencies other than 3.2768kHz, so reducing interference. It has been suggested that an active filter would actually generate interference in the form of cross modulation. In field tests, interference levels were not found to be sufficiently high for this to occur. The filter output is then fed to IC3, an LM380 audio amplifier, and level is controlled by RV3. The output feeds a pair of headphones via socket SK1.

The T/R switch, SW2, has a 3rd position marked 'S' which stands for 'safe' or 'standby'. On the first prototype this position wasn't present and it was found that on switching from TX to RX the LM358 and, occasionally, the expensive SL1640 ICs were destroyed. This was put down the the fact that C19 gets charged to a high potential (since it forms part of a resonant circuit the voltage will be greater than 24V) during TX, the potential being discharged across IC1 on switching to RX. The purpose of the 'S' position therefore (which comes between RX and TX on the rotary switch) is to discharge the capacitor across R23 before connecting it to the receiver input stage.

The final transmitter amplifier is driven directly from the dual battery +24V supply. A +12V supply from a single battery is used for powering the LM358 and LM380 and the SL1640 is powered from this supply in conjunction with the 6.3V zener diode which gives the required supply. The +5V supply for the logic ICs is generated from the +12V supply by IC8, a 7805 voltage regulator.

equipment. The loop aerial is of such size that it will have to be carried separately. The remaining equipment consists of the transceiver, two 12V lead acid batteries, a pair of headphones, a morse key and a lead for connecting the aerial. Carrying these separately would both be very inconvenient and make them prone to damage by water.

Ammo boxes make a very convenient container. These are widely used by potholers to carry photographic equipment underground. They are of a strong construction with a tight waterproof seal and are available at modest cost from army surplus stores and caving shops. The preferred size is 12"x6"x7", which will easily accommodate the equipment. In order to give extra protection against shock and ensure that the various items do not knock against each other the box can be filled completely with a dense foam rubber into which pockets are cut of just the right size to take batteries, ABS plastic box, headphones, morse key and anything else you may need.

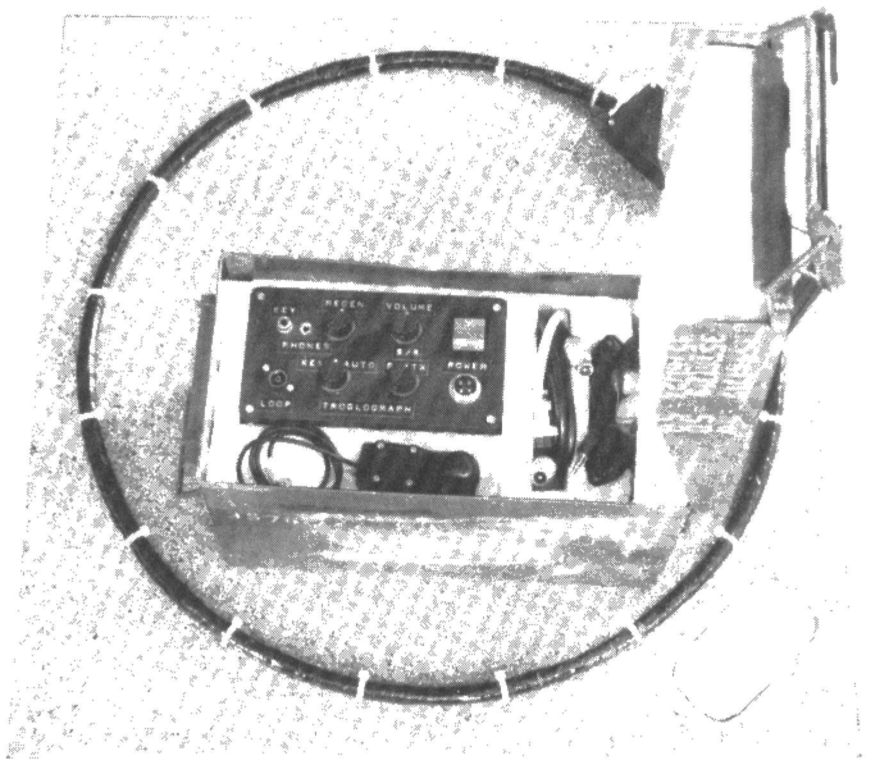
BUYLINES

Nothing problematic about the electronic components. The SL1640 is available from Cirkit and the PCB will be available from us, but see the note in News Digest. Batteries can be bought from electronic component suppliers or, more cheaply, from suppliers of burglar alarm equipment. Large quantities of enamelled copper wire are likely to prove expensive — shop around the surplus stores or try the Scientific Wire Company, 118 Forest Drive, London E17 (tel: 01-531 1568). Ammo boxes are widely available from army surplus stores or caving shops. Morse keys are available from amateur radio shops, sometimes from surplus shops and even from Maplin, PO Box 3, Rayleigh, Essex SS6 8LR (0702-552911). The Maplin models — which will require housing and connection to a suitable lead — are LQ00A for beginners at £1.95 and LQ01B at £4.95. You may prefer something rather more compact — especially to take the Troglograph caving — in which case it would be an easy matter to make a boxed and water-proof keyer using any suitable momentary contact push-to-make switch. Although not absolutely necessary, waterproof connectors may be a good idea. Cirkit, Park Lane, Broxbourne Herts (0992-444111) carry a range of Bulgin connectors with 18 varieties including BNC co-ax and 3-pin panel mounting going under the generic name 'Buccaneer'. Finally, the recommended headphones are sold for personal stereos and are widely available and inexpensive.

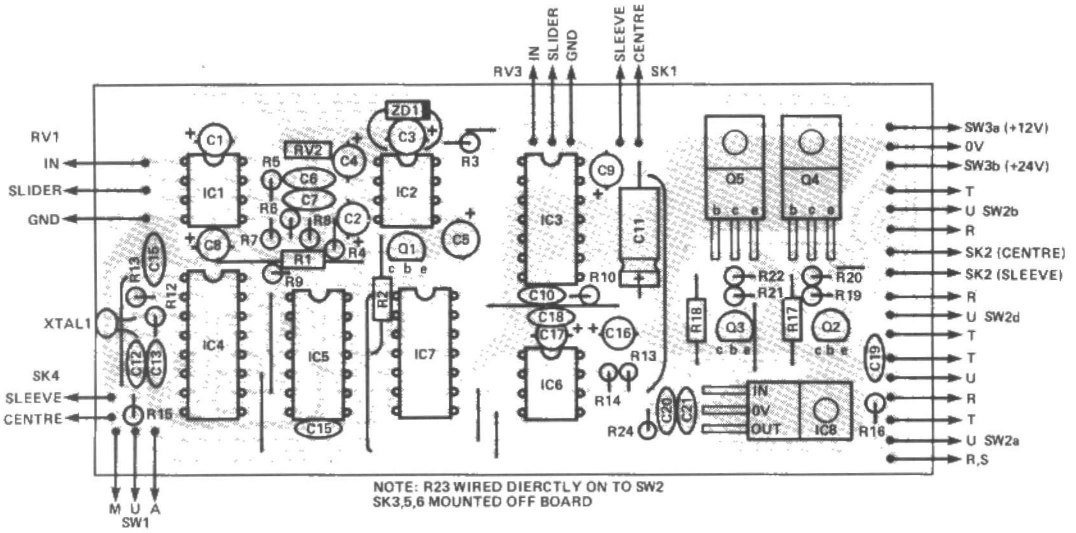
PARTS LIST

RESISTORS (all ¼W, 5%)	
R1, 7, 15, 16	10k
R2, 12, 17, 18	100k
R3	330R
R4	12k
R5	220k
R6, 8, 9, 19, 20, 21, 22	1k0
R10	2R2
R11	6M8
R13	1M0
R14	470k
R23	8R, 1W
R24	4k7
RV1	100k variable
RV2	1k0 min vert preset
RV3	10k log variable
CAPACITORS	
C1, 2, 3, 16, 17	1μ 16V tant
C4, 5, 8, 9	2μ 16V tant
C6, 7	10n polyester
C10	100n polyester
C11	100μ 25V electrolytic
C12, 13	82p ceramic
C14, 15, 18	10n ceramic
C19	400V polyester (see text)
C20	470n polyester
C21	220n polyester
SEMICONDUCTORS	
IC1	LM358
IC2	SL1640
IC3	LM380
IC4	4049
IC5	74LS93
IC6	NE555
IC7	74LS90
IC8	7805
Q1, 2, 3	BC337
Q4	TIP125
Q5	TIP120
ZD1	BXZX88 6V2 zener
MISCELLANEOUS	
	SK1
3.5mm jack socket	SK2, SK3
Belling Lee co-ax sockets	
SK4	Phono socket
SK5	3-pin panel mounting plug (CB mic connector suitable)
SK6	In-line socket to match SK5

SW1 SPDT; SW2 4P3T rotary; SW3 DPST; B1, B2 12V 2.6/1.9AH lead acid batteries; XTAL1 min 32.768kHz crystal; 120 turns of 22SWG enamelled copper wire on a 19 inch former (1.5kg); co-ax cable and two Belling Lee co-ax plugs; small ABS box (71x46x22mm) for loop termination; large ABS (box 99x119x44mm) for main board; ammo box (12"x6"x7"); foam rubber to pack ammo box; morse key with phono plug on lead; 32R phones fitted with 3.5mm jack plug; PCB.



The Troglograph in its ammo box



NOTE: R23 WIRED DIERCTLY ON TO SW2
SK3,5,6 MOUNTED OFF BOARD

Fig. 7 Overlay diagram for the Troglograph.

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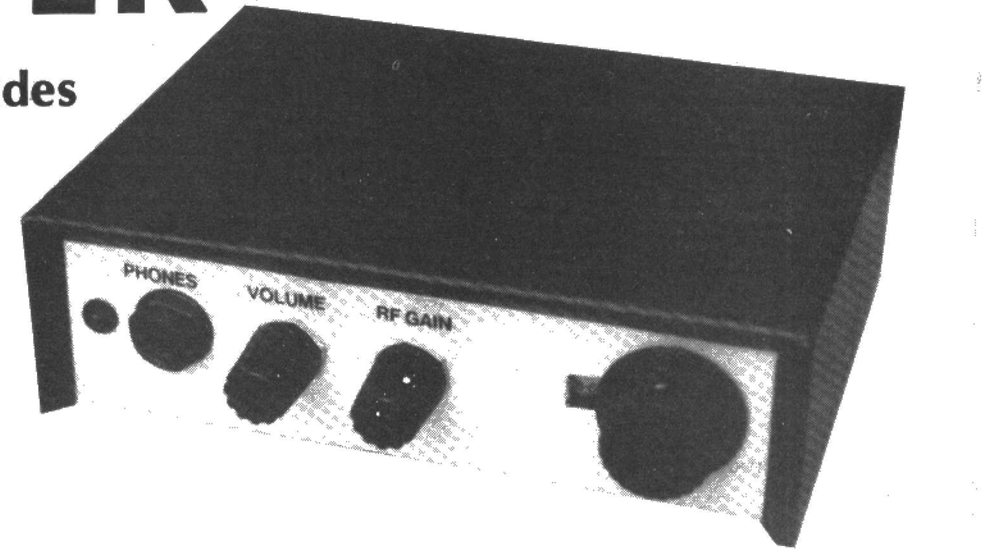
80m DIRECT CONVERSION RECEIVER

S. Niewiadomski concludes his description of this project for the 80m amateur band.



With the exception of the controls, the sockets and the power-on LED, all of the components mount directly onto a single-sided PCB. Ready-etched boards will be available from our PCB Service, but it is not difficult to etch your own if your prefer. It is some time since we last described the process so it won't hurt to go through it again here.

The first stage is to either photocopy the pattern shown on the foil patterns page or trace the hole positions onto a piece of transparent or translucent paper. If the photocopying method is used, make sure that the original dimensions are maintained on the copy, as many photocopiers produce distorted copies.

Cut a piece of single-sided copper-clad board to the correct size and shape and stick the photocopy or tracing onto the board. Mark the position of each hole (including the 3mm fixing holes) onto the board with a centre punch and hammer. Then remove the paper and drill and deburr the 3mm fixing holes. Clean the board with a liquid abrasive cleaner such as Jif, then rinse and dry it.

The track pattern can now be carefully drawn on the board with an etch resist or Dalo pen, using the hole marks as a guide to the track positions. It can be seen that only the minimum amount of copper is removed from the board, the unetched area being used as an earth plane. This improves the RF performance of the PCB and means that the board is etched quickly, using up only a small amount of etchant.

When all the tracks and the earth have been drawn, allow the ink to dry for at least 15 minutes. Insert a piece of insulated wire through two of the fixing holes and immerse the board in a bath of ferric chloride solution trackside-up. Agitate the solution by moving the board around using the wire until etching is complete. Because so little of the original board surface is exposed, etching will be rapid. Remove the board from the solution, rinse it, and clean off the resist ink with a suitable solvent. Drill the remaining holes with a 1mm drill, then open out the holes shown to 1.5mm. The board is now ready to have the components mounted on it.

Work methodically, starting at one corner of the board and progressing to the opposite corner mounting each component as it occurs but leave the semiconductors until last. This system is to be preferred to mounting say all the resistors first, then the capacitors, and so on as it results in less errors. Take the normal handling precautions with the JFETS, ensuring that your soldering iron is earthed. On the prototype receiver, all the ICs were fittted in sockets without any problems occurring. Fault-finding is made much simpler if a suspect IC can easily be removed. When all the components have been fitted onto the board, carefully check the orientation of the polarity sensitive devices, and ensure that no solder bridges or splashes exist.

The Case

A ready-made case is used to house the receiver, greatly simplifying the metal working required. Drilling and cutting details for the chassis are given in Fig. 2. It is best to obtain all the components which have to be mounted on the chassis before starting work because physical details might differ slightly from those on the prototype. Any type of LED may be used for the power-

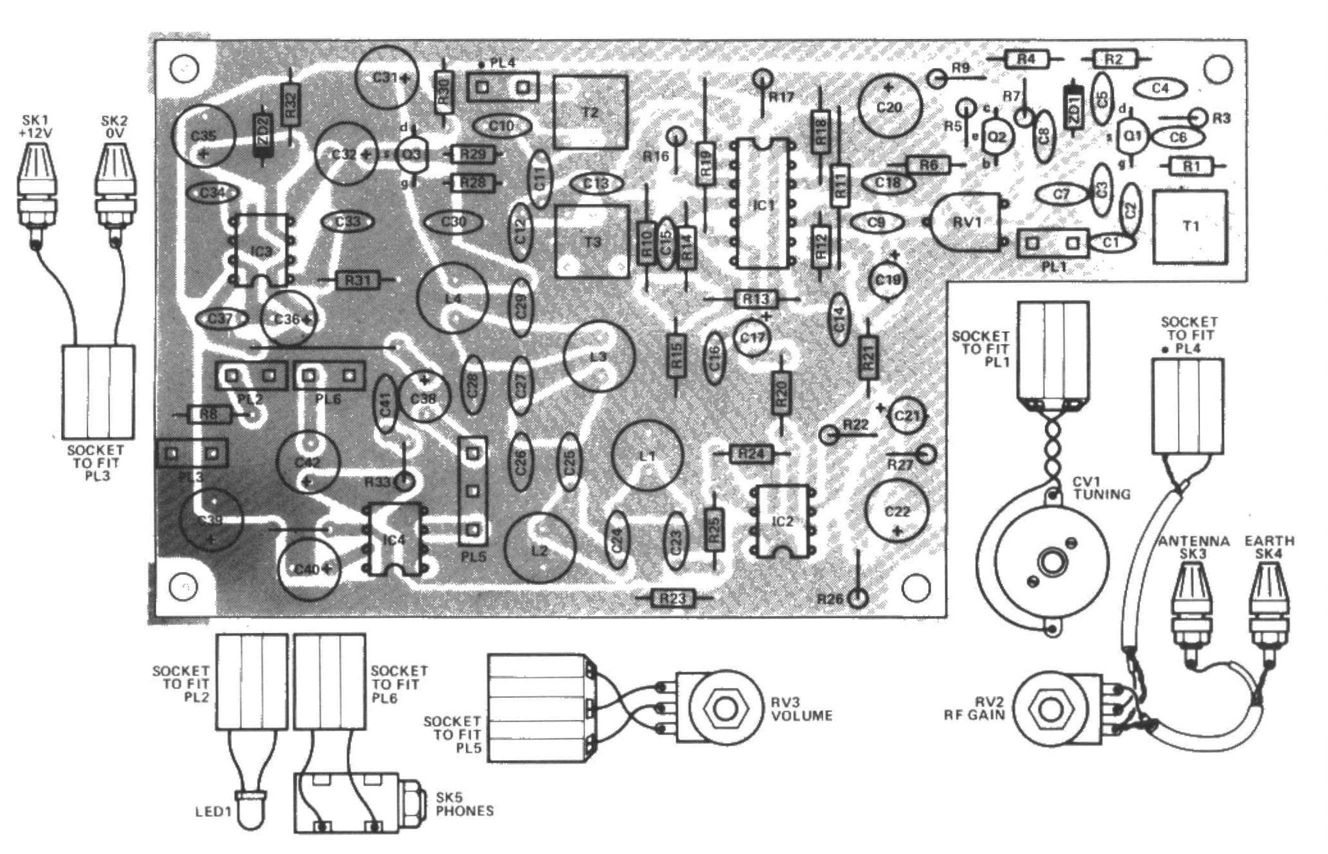


Fig. 1 Component overlay for the receiver PCB.

PARTS LIST

RESISTORS (all ¼W, 5%)

R1, 22	100k
R2, 7, 9, 16, 23, 30, 33	100R
R3	150R
R4	270R
R5	22k
R6, 17, 20, 21	10k
R8	1k5
R10, 14, 15, 25-29	1k0
R11	1k2
R12	560R
R13	820R
R18, 19	2k7
R24	39k
R31	1M0
R32	390R
RV1	470R horizontal skeleton preset
RV2	470R linear potentiometer
RV3	10k logarithmic potentiometer

CAPACITORS

C1	390p ceramic
C2	270p ceramic
C3	100p ceramic
C4-6, 8, 14-16, 18, 34	10n disc ceramic
C7, 9	1000p ceramic
C10, 12	39p ceramic
C11	6p8 ceramic
C13	22p ceramic
C17, 19, 38	1u0 35V tantalum
C20, 22, 31, 32, 35, 39, 42	100u 25V radial electrolytic
C21, 40	10u 16V tantalum
C23, 25	270n polyester
C24	180n polyester
C26	100n polyester
C27	12n polyester
C28	120n polyester
C29	33n polyester
C30	82n polyester
C33	47u 6V3 tantalum
C36	2u2 16V tantalum
C37	4n7 ceramic
C41	47n polyester
CV1	100p variable capacitor, Jackson type C804

SEMICONDUCTORS

IC1	MC1496
IC2	TK071
IC3	SL6270C
IC4	LM386
Q1, 3	BF256
Q2	BF241
ZD1, 2	6V2 400mW zener
LED1	red LED

MISCELLANEOUS

L1,2	390mH (Toko)
L3	47mH (Toko)
L4	39mH (Toko)
PL1-4, 6	3-way 0.1"pitch PCB plug
PL5	5-way 0.1"pitch PCB plug
SK1	red 4mm terminal
SK2	black 4mm terminal
SK3	blue 4mm terminal
SK4	white 4mm terminal
SK5	mono ¼" jack socket
T1	KANK3337R (Toko)
T2, 3	KANK3333R (Toko)

PCB; case, 154 x 120 x 45mm; stick-on feet, 4 off; two-speed reduction drive, Jackson type 4511/DRF; dial for CV1 (see text); metal for CV1 mounting bracket; control knobs, 2 off small and 1 off large; IC sockets if required, 3 off 8-pin DIL and 1 off 14-pin DIL; cable shells and crimp terminals to suit PL1-6, 5 off 3-way and 1 off 5-way; nuts, bolts, studding, co-axial wire, etc.

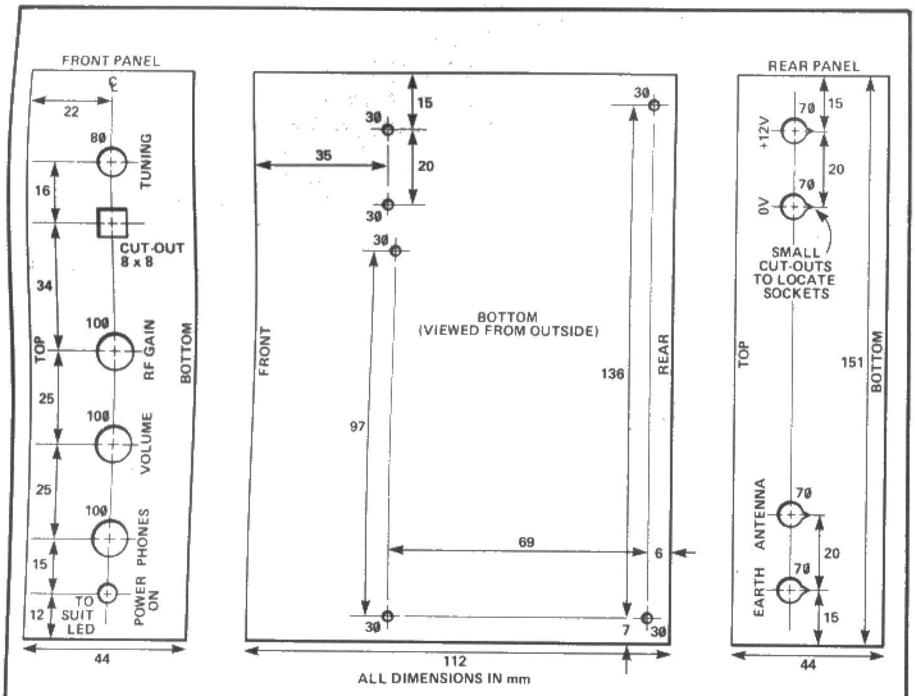


Fig. 2 Details of the holes required in the case.

on indicator, or it could be omitted altogether.

Figure 3 shows the dimensions for the aluminium bracket on which CV1 and the slow motion drive are mounted. Again it is best to cut, bend and drill this bracket before drilling the chassis so that slight inaccuracies can be corrected without having to file oval holes. Figure 4 shows the tuning dial, which on the prototype was made from unetched single-sided PCB material. This is easy to work and gives an acceptable background to rub-on lettering when the dial is calibrated.

When the chassis metalwork is finished and all the components have been shown to fit onto it correctly, the front panel can be rubbed-down and painted if required. Lettering can be applied and finally a coat of clear lacquer sprayed on as protection.

Figure 5 shows how the slow motion drive and CV1 are fitted to their mounting bracket. Two 25mm lengths of 6BA studding and 6BA nuts are required to space the drive from the bracket. The tuning dial is secured to the slow motion drive with two 8BA screws.

The positions of the major items which fit into the chassis can be seen in the photograph. The PCB is held in place by ½" long 6BA screws which are first fixed in the chassis with two 6BA nuts. The board is then fitted over the protruding parts of the screws and further 6BA nuts used to secure it.

The wiring details are given in Fig. 1 and can be checked against the photograph. All connections to the PCB are via plugs (on the board) and sockets (on the wires). The connections between SK3, SK4, RV2 and PL4 are made using miniature co-axial cable. Wire the other connections using twisted pairs (or triple in the case of RV3) and fit sockets at the PCB ends.

One nice feature of direct conversion receivers is that they are generally easy to align, and this one is no exception. When all the wiring has been completed and carefully checked, connect a well-stabilised 12 volt supply capable of providing about 100mA. If available, use a milliameter with an FSD of at least 100mA and connect it in series with one supply lead. Switch on and check that the current is about 65mA. If it is significantly more than this, switch off quickly and re-check all the wiring. Look also for short circuits on the PCB.

When all seems to be well and the supply current is at about 65mA, check that the power-on LED lights. If it does not, it is probably connected the wrong way round.

Alignment

Despite any advice I might give here about methodical checking and alignment, the chances are that you will want to plug in your headphones and have a listen. Go ahead — the beauty of a direct conversion receiver is that there is a good chance you will hear some stations as it is tuned.

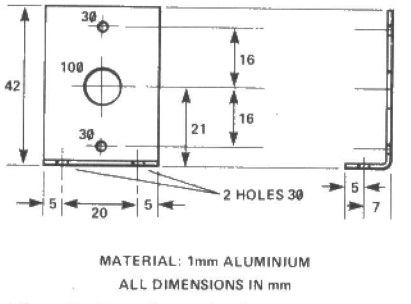


Fig. 3 Details of the mounting bracket for CV1 and the reduction drive.

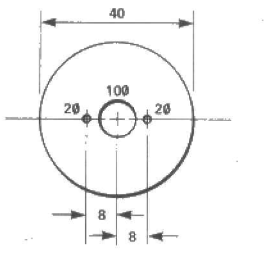


Fig. 4 Details of the tuning dial.

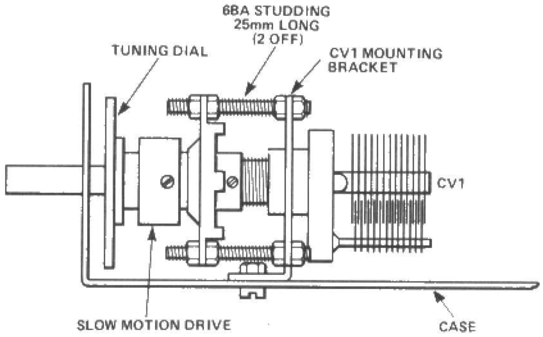
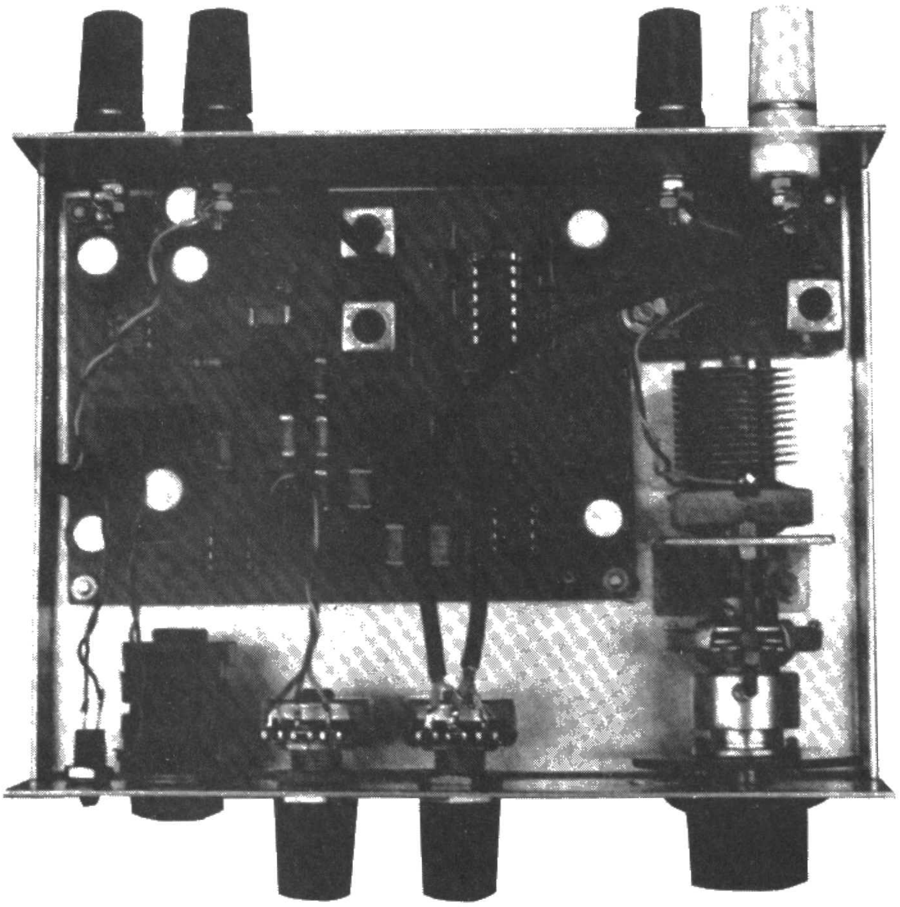


Fig. 5 The mounting arrangement for CV1 and the reduction drive.



The first task of alignment is to get the VFO output level and frequency coverage correct so that the whole of the 80m band can be received. If an oscilloscope is available, monitor the wiper of RV1 and adjust it to obtain an output of approximately 300mV peak-to-peak. If an oscilloscope is not available, set RV1 to about mid-way and its final adjustment can be made by listening to its effects on received stations.

To set the frequency range of the VFO accurately, a frequency counter or a receiver (preferably with digital read-out) is required. Set CV1 to maximum capacitance (that is, with its vanes fully meshed) and adjust the core of T1 to give a frequency of about 3450 kHz. Now swing CV1 to minimum capacitance and check that the frequency is around 3850kHz. These extremes are not critical and if a smaller or larger range is obtained, it does not matter as long as the range of 3500–3800kHz is covered. For the avid experimenter, the range can be altered by changing C1 and C2 if, for example, the CW section of the band (3500–3600kHz) is not required.

The only other adjustment which has to be carried out is the peaking of the input RF filter coils, T2 and T3. If a signal generator is available, set it to approximately mid-band (say 3650kHz) and tune the VFO to give an audio frequency beat. Adjust the cores of T2 and T3 alternately while monitoring the output of IC2 until maximum signal is obtained. When this has been done, the tuning dial can be calibrated by setting the signal generator in 50kHz steps and marking the tuning dial with the positions at which zero beats are obtained. When the whole band has been covered, remove the tuning dial and neatly Letraset and lacquer it. This completes alignment.

Using The Receiver

The results obtained from any receiver depend greatly on the antenna used and the amount of practice and patience exercised by the user. Acceptable results can be obtained with a simple indoor antenna consisting of a few metres of wire draped around a room. Better results will be obtained with an outdoor antenna. This can range from a simple 'long wire' mounted as high and as far away from obstructions as possible to an antenna designed specifically for the 80m band.

There was not enough room to mount a loudspeaker in the case of the receiver, but if a small enough loudspeaker can be found or a larger case is used, by all means use an internal loudspeaker. There is enough power to drive an external loudspeaker if required, or low impedance headphones can be used.

Receiving SSB transmissions can be a little difficult at first. Tune around the band on the fast speed of the slow motion drive until a transmission is heard, then back-off the tuning on its low rate. Two tuning positions will be found where the voice pitch sounds correct, but one will result in garbled speech and the other in intelligible speeach. If distortion is heard, rotate the RF gain control anti-clockwise until it disappears.

It is worthwhile commenting on the performance of the audio AGC IC used. After setting the volume control for a comfortable listening level, local and more distant stations can be tuned in and heard at the same level without adjusting the volume control. This contrasts with the normal performance of direct conversion receivers where changes in the input signal level result in changes of the audio output and frequent adjustments of the volume control are necessary.

BUYLINES

The electrolytic and polyester capacitors used in the prototype were all made by Siemens and can be obtained from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB, tel 0784 - 33603. The MC1496 is available from Cirkit and Technomatic, the TL071 from Technomatic and Electrovalue, the SL6270 from Cirkit and the LM386 from Technomatic. Watford can supply all four devices. The Toko coils and transformers are all available from Cirkit and from Bonex Ltd, 102 Churchfield Road, Acton London W3 6DH, tel 01-992 7748. The Jackson products (CV1 and the reduction drive) can be obtained from WPO Communications, 20 Farnham Avenue, Hassocks, West Sussex, tel 079 18-6149. Cirkit stock suitable PCB plugs and sockets and the case can be obtained from Electrovalue, catalogue number SB2. The PCB will be available from our PCB Service, but see the note in News Digest.

ETI

DIGITAL SOUND SAMPLER

Paul Chappell discusses the construction and setting-up of the digital board.

The component layout for the digital board is shown in Fig. 1. All the ICs can be socketed, if you wish, since there are no through connections made on their leads. The bad news is that this means a lot of through connections made by wire links, so be careful not to miss any.

In the light of experience, it has been necessary to make a few minor changes to the circuit which appeared in the February 1986 issue of ETI. IC10 has been changed to an LS151, since we discovered that the LS152 was virtually unobtainable. It does exactly the same job. C4 and C5 in the phase locked loop section have to be chosen as a compromise between various performance factors, and higher values have been chosen than those originally specified. It was found necessary to apply a hardware reset to IC16, so the preset pin (pin 4) of this IC now goes to the main reset line. If you find any discrepancies between the circuit and the PCB, the board is correct. The one substantial change is shown in Fig. 2.

Testing

The first steps are best carried out without the computer or the analogue board connected. IC1 must oscillate at a frequency close to 2MHz, so solder in a 1k resistor for R2 and a 1k pot on flying leads (short ones!) for RV1. Adjust RV1 so that the frequency at IC2 pin 2 is 2MHz. The waveform at this point must have an even mark to space ratio, and a slight adjustment to the value of R16 may be needed to achieve this.

Next, check that square waves of different frequencies, from approx. 4kHz to 8 kHz, are appearing at the outputs of IC2. This IC is a frequency divider which divides down the input to pin 2 to produce frequencies corresponding to an octave of the equal tempered musical scale.

The function of IC2 is to select one of these frequencies from IC2 according to the code on pins 15, 14, 13 and 11. If some frequency or other in the range 4kHz to 8kHz is present on pin 10, you can proceed to set up the phase-locked loop. If you are really keen to test this IC thoroughly, the way to proceed is as follows:

Remove IC9 from its socket, and apply binary codes to the select pins of IC3 (pins 15, 14, 13 and 11). As pull-up resistors normally hold these pins to a logic '1', all you need to do is to ground the pins where you want a logic '0'. Stepping through from 0000 to 1011 should select all the outputs of IC2 one at a time. 1100 to 1111 should result in pin 10 remaining at logic '0', since the corresponding inputs are tied to logic '1' and the output of the IC inverts.

To set up the phase locked loop, set RV2 to mid position and remove R3 from the circuit to allow the oscillator in IC4 to run freely. The loop contains a divider chain consisting of IC5, IC6 and IC7 which divides the output frequency from IC4 pin 9 by 200. We are aiming for a frequency of about 6kHz at the phase comparator input (IC4 pin 3), so C6 and CV1 must be adjusted to give an output of 1.2MHz. A value of 470p for C6 and 100p for CV1 should allow the output to be set to this frequency. To trim the frequency further, use a double beam 'scope synchronised to IC2 pin 10, and adjust CV1 until the trace from IC4 pin 3 stands still and has the same number of pulses per division as the trace from IC2 pin 10. Don't worry if the trace from IC4 won't stand perfectly still; it's the number of pulses per division that is important. As a phase locked loop with a divider chain can easily lock onto harmonics, make sure to get this adjustment right. If you cannot get the frequency low enough, increase the value of C6, and vice-versa.

PARTS LIST

RESISTORS
(all ¼ Watt 5% unless stated)

R1	**68k**
R2	**see text**
R3	**22k**
R4	**10k**
R5	**1k0**
R6	**1k0**
R7	**1k8**
R8	**100R**
R9	**330R**
R10, 11, 12, 13	**4k7**
R14	**1k0**
R15	**470R**
R16	**47k**

CAPACITORS

C1	**100p ceramic**
C2	**10n ceramic**
C3	**10μ 6V tant**
C4	**470n 6V tant**
C6	**see text**
C7	**10μ 6V tant**

All decoupling capacitors, 100n ceramic

SEMICONDUCTORS

IC1	**74CO4**
IC2	**M083**
IC3	**74C150**
IC4	**NE564**
IC5	**74LS163**
IC6, 7, 11	**74LS162**
IC8	**74LS374**
IC9	**7407**
IC10	**74LS151**
IC12, 14, 15, 16, 17, 22	**74LS74**
IC18	**74LS132**
IC19	**74LS02**
IC20, 21	**74LS00**
IC23, 24	**74LS541**

MISCELLANEOUS
8-way, 12-way and 15-way 0.1" pitch Molex connectors, 5-way 0.2" pitch connector, IC sockets as required, PCB.

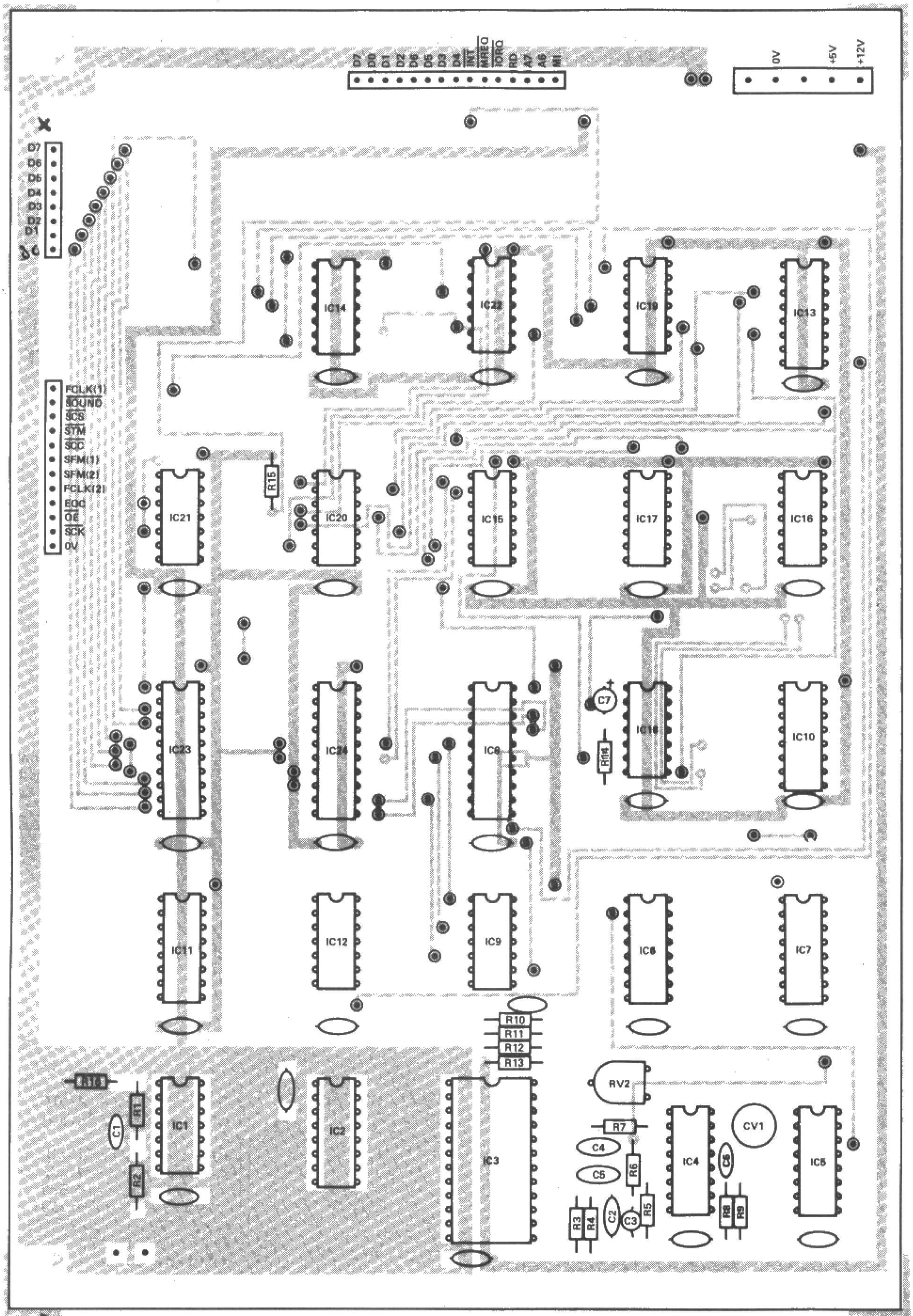


Fig. 1 Component layout for sound sampler digital board.

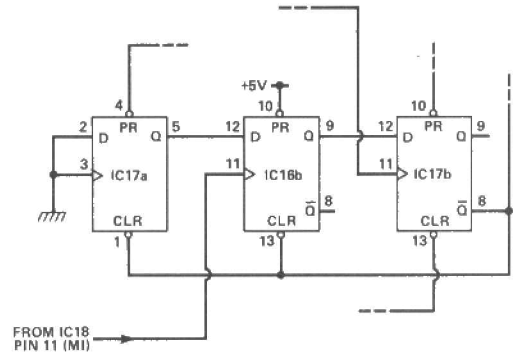


Fig. 2 Change to digital circuit. All unmarked connections are the same as in the circuit on page 43 of the February, 1986 issue of ETI.

Now, replace R3 and check that the PLL will lock onto the input frequency over a 2:1 range. The easiest way to do this is to increase the oscillator frequency with RV1 until the loop goes out of lock (the pulses at pin 3 of IC4 become irregular) and then reduce the frequency until it just pulls into lock again (the pulses at IC4 pin 3 become regular and match the frequency at IC3 pin 10. Make a note of the number of pulses per division, or the number of pulses across the entire graticule. Do the same at the low frequency side: reduce the oscillator frequency until the loop is out of lock, bring it to the point where it just locks again, then make another note of the number of pulses per division. If the first reading is not at least twice as high as the second, rotate RV2 anti-clockwise and repeat the measurements. Continue until the loop will lock over a 2:1 range, then rotate RV2 just a little further anti-clockwise to allow for drift, and then leave it.

The purpose of RV1 is to allow fine tuning of the sampler to bring it into line with other instruments. One semitone is the entire range needed, so RV1 should be low in value. Too high a value will allow adjustment to the point where the PLL can no longer lock onto the input frequency, and as this could prove quite embarrassing when you are on stage, it is best avoided. Set RV1 to give 2MHz output from the oscillator, then measure the combined resistance of R2 and RV1. Select the nearest preferred value (in the E96 series, if possible) below the measured resistance and solder this in place of R2. Then, use the lowest value of pot you can find for RV1 — 10R should be about right. If you can't get hold of a 10R pot, use a slightly larger value and connect a suitable value of fixed resistor in parallel. This will restrict the main adjustment range to a small area of travel of the pot, but it shouldn't be difficult to tune.

For further testing, the analogue board must be connected. Make sure that the power connections for both boards, especially the 0V lines, are taken to the supply through fairly thick wire — 24/0.2 will do admirably — and keep the connections fairly short. A short length of the same wire should be connected between the 0V power supply points on the two boards. Switching noise on the power lines can cause all kinds of hiccups, and is made very much worse by poor supply connections, so ignore this advice at your peril! The control and data line connectors for the two boards have been arranged so that they are opposite each other and close together. Keep the connections between them short — about 2" to 3" of ribbon cable should be OK.

Remove IC8 from its socket and ground pins 8, 9 and 10 of IC10. Check that there is a signal present at IC10 pin 6, IC11 pin 15 and IC12 pin 5. Next, look at IC21 pin 6. This is a signal from the A-to-D converter on the analogue board and goes low during the conversion process. Since the conversion cycle takes place continuously, whether or not the results are used, this signal should go low periodically to indicate that this is happening. With the 'scope still synchronised to IC21-6, use the other trace to look at IC21-3. This should oscillate at the same frequency as IC10-6, except that when IC21-6 is low, it should remain high. This is the clock for the mobile filter of the A to D section, and the high state during the conversion is the 'hold' signal.

Now turn off the power to the board, replace the ICs you have removed, and disconnect any links you have made for test purposes. Turn the power back on and check that the reset has operated: IC14-5, IC14-9, IC15-5, IC15-9 and IC16-6 should all be low. Now — an important test — check that all data, address and control lines (except INT) on the computer connector at the top of the board are floating. Take a 1k resistor from each line to ground, then to +5V, and make sure they are free to follow the input. INT should be the only one which is driven to a definite logic level. If this is not the case, it indicates a fault which could damage your Spectrum, so don't connect the computer until you have found out the cause. If the data lines are not floating, see whether IC23, IC24, IC11 or IC22 are enabled. They shouldn't be, so follow the enable signal back to find out why. As all the other signals, except for INT, are inputs, the most likely causes of fixed voltages on these lines will be either a faulty IC (follow through to find which IC the faulty line is connected to) or else a track short. If all is well, you are ready to connect the computer and sample some sounds. This will be described in the final part of this series, next month.

BUYLINES

IC1 and IC3 are 74Cxx types because they are required to operate at 12V, because of the M083 top octave generator. The M083 itself is available from Maplin, PO Box 3, Rayleigh, Essex SS6 8LR (tel: 0702 552911) price £4.45 (order code: YY81C). The 74C04 is actually a direct equivalent of the more familiar 4069 hex inverter and is therefore widely available. The 74C150, a 16-line to 1-line multiplexer, is another matter. It is available from Farnell, Canal Road, Leeds LS12 2TU (tel: 0532 636311). In some circumstances, Farnell will deal with the general public (for example, if you are a student engaged in a special project they may consider you). Normally, you will have to order the chip through a dealer who maintains an account with Farnell. This should not present a major problem. You can always order Farnell stock through Trilogic, 29, Holme Lane, Bradford BD4 0QA (tel: 0274-684289), for a small fee. None of the other components present any problems. The PCB will be available from our PCB service, but see the note in News Digest. **ETI**

GRANNY ISOLATOR

Andrew Armstrong introduces the concept of the opto-isolated-OAP.

One of the privileges of retirement is staying up late. No more trains to catch, no more clocking on, no more propping up the eyelids over a cup of instant coffee, trying to look lively when your boss (or, alternatively, your employees) drops by after the late late night-before. You can play pool till 6 am, carouse till the second cock or watch the Open University into the wee small hours, and suffer no consequence more serious than an unexpected parcel arriving at 7.30 am.

Another privilege of retirement is the freedom to go to bed at 9 pm with a good book (or whatever) with no fear that that vital report won't be ready the following morning, or that your office togs aren't pressed. The catch is that privilege (1) and privilege (2) don't make good next-door neighbours, especially if you are a little hard of hearing (as is a friend of mine) and a light sleeper (as is her neighbour). My friend likes to keep her television company till closedown, at a volume level which keeps her neighbour awake till closedown. They appealed to me for a solution.

The obvious solution to listening and watching late at night is to use headphones. Some televisions are equipped with headphone adaptors, but the majority are not. Television sets are live to the mains, so direct connection of headphones is not safe. Hence this project is an isolator.

Frequency Response

The most obvious means of connecting headphones to a television is to use a loudspeaker transformer. I considered this and rejected it for two reasons. First of all I could not find a suitable transformer in any of my catalogues, and second I wanted to modify the frequency response to improve the intelligibility of speech even at the expense of some musical quality. A boost to the middle frequency range, relative to the bass and treble, can provide higher intelligibility for a given volume. This, I hoped, would reduce the likelihood of hearing fatigue being induced by wearing headphones for longish periods.

The scheme I settled on was to transfer the signal from television to headphones via an opto-isolator, and some associated electronics.

I have tried using an opto-isolator for this type of task before, with little success. Using a simple system of linear signal transfer, with the base of the phototransistor unconnected, there was nothing I could do to prevent it from picking up a loud buzzing, presumably related to the switched mode power supply, the rectifiers, or the timebase. A pulse width modulation system seemed much more promising, and now seems to work well.

Such a system is more complicated than a straightforward linear system, but the results appear to justify it. The scheme for generating a pulse width modulated signal is shown in Figure 1. This leads neatly to the next design decision, the choice of switching frequency.

It also gives rise to another consideration. The average opto-isolator, when used in its normal manner, cannot switch cleanly at this speed. It gives out a rather limp-looking triangle wave. In order to make it operate faster, the collector/base junction of the phototransistor has to be connected as a photodiode. This, of course, gives virtually no signal output, as can easily be determined from the Law of Conservation of Misery.

The signal from the opto-isolator therefore has to be squared up by a comaprator before it is of any use, after which the high frequency component of the waveform is filtered out, leaving the averaged audio signal. This can be amplified by a conventional amplifier circuit, and fed to a pair of headphones. The amplifier circuit shown here uses an op-amp and transistors, simply because these components were to hand at the time of building. A small amplifier IC would be equally suitable.

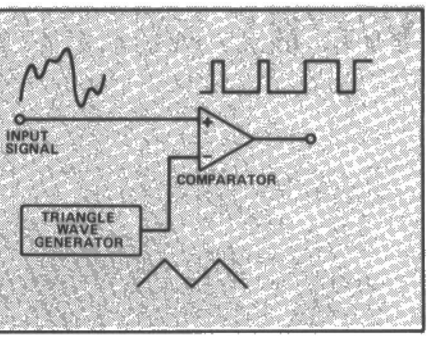


Fig. 1 Generating a pulse-width modulated signal.

Circuit Details

Some of the details of the circuitry comprising the blocks described deserve mention. First of all, the frequency shaping network is designed to produce a voltage gain of two at the extremes of the frequency range, but to provide a gain of almost five in the middle of its frequency range. The corner frequencies are nominally 234 Hz and 3386 Hz.

The triangle wave generator produces a waveform of approximately 1V peak to peak, at a frequency of approximately 45 kHz. A fast op-amp which is not unity-gain stable is used as a comparator, and a unity-gain-stable version of the same thing is used as the integrator. In order to prevent the power supply from influencing the waveform, the square wave signal fed to the inte-

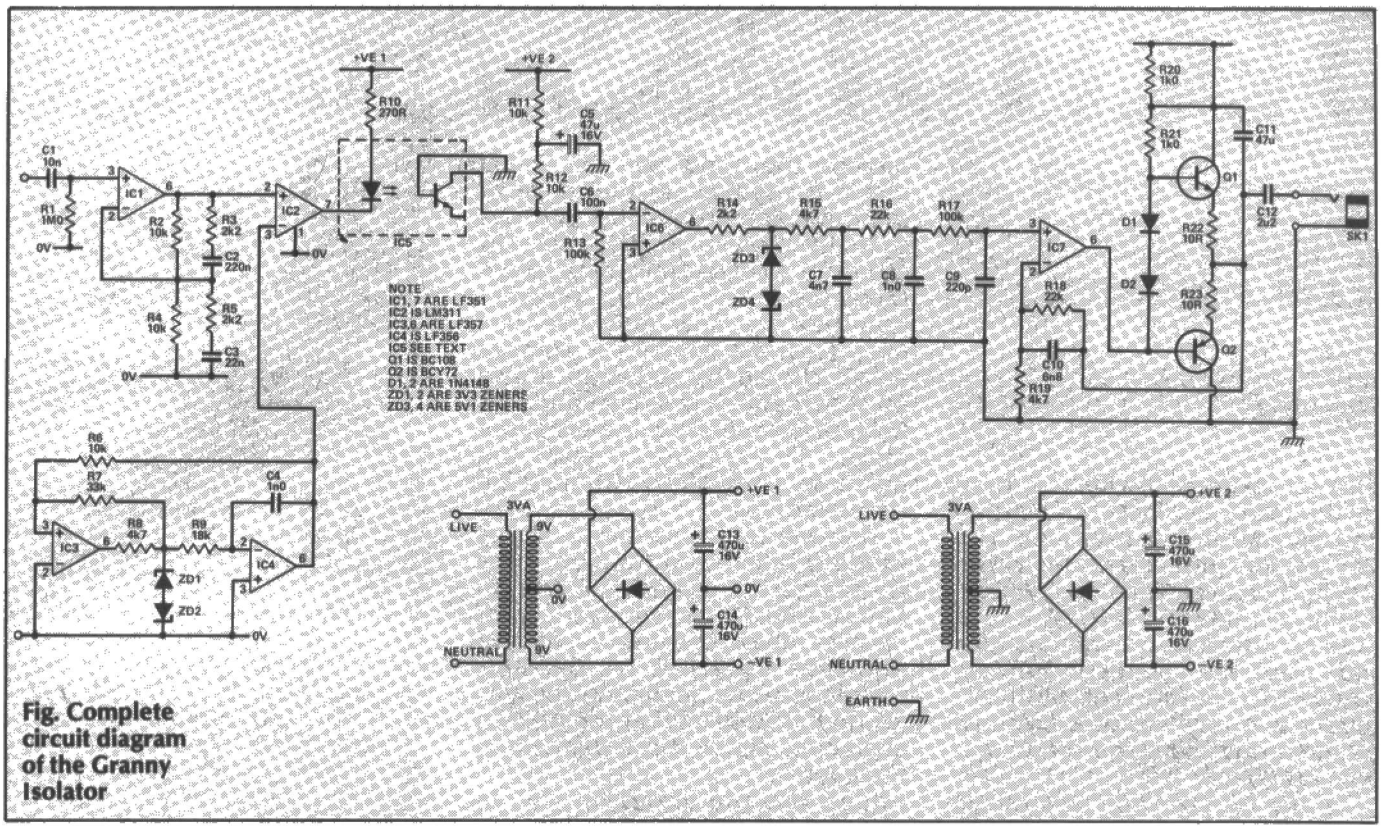


Fig. Complete circuit diagram of the Granny Isolator

NOTE
IC1, 7 ARE LF351
IC2 IS LM311
IC3,6 ARE LF357
IC4 IS LF356
IC5 SEE TEXT
Q1 IS BC108
Q2 IS BCY72
D1, 2 ARE 1N4148
ZD1, 2 ARE 3V3 ZENERS
ZD3, 4 ARE 5V1 ZENERS

grator is clipped symmetrically by a pair of back-to-back zener diodes, so it cannot run into the supply rails.

The triangle waveform is compared with the audio signal to generate the switching waveform. The choice of the LM311 comparator for this job was largely because it has an output stage which can sink substantial currents to 0V, even though it is powered from + and − supplies.

The optoisolator can be almost any ordinary transistor type, but Darlington types are not suitable. There are also a few transistor types which are not fast enough. I used a 4N27 from the bits box.

On the 'safe' side of the circuit, the supply to the collector of the opto-isolator is decoupled by a 47u capacitor, because the power supply does not use voltage regulators, and thus will cause hum on the sound given half a chance. The output from this is fed to another LF357 used as a comparator, and once again its output is clipped by back-to-back zener diodes to prevent the power supply ripple from interfering with the sound. After this the signal is fed to a cascaded RC filter which reduces the 45kHz components of the signal to negligible levels, while leaving the audio. A bit of extra rolloff is provided in the amplifier, by C10, to attenuate any high frequency hiss and interference which may be present.

The output of the amplifier is coupled to the headphones via 2u2 capacitor, which is an unusual value to use. This was chosen because the original circuit picked up a background hum of 50Hz, which could not be eliminated by any other simple means. The 2u2 capacitor, in conjunction with the impedance of the headphones, attenuates such low frequencies.

The Headphones

Suitable headphones for this job are ones which are comfortable to wear for a long time, without costing an arm and a leg. There do exist monophonic headphones specially designed for TV and video listening, a fact which I did not discover until I went shopping for a suitable set. The pair I found, for those who may be interested, are the Ross RE-228TV, which I purchased for £11.50 in the Tottenham Court Road, although others are available. These headphones are wired for mono, and are provided with a volume control near the headphone end of the lead. The lead itself is about three times as long as on most 'phones, to enable the viewer to sit at a comfortable distance from the set. Other types of headphone will do as well: I was looking for a pair which were light, had largeish, foam earpads and for preference a bit of padding in the headpiece. The large 'earmuff' type phones tend to be heavy for an elderly person, and personal stereo headphones are often hideously uncomfortable after prolonged wearing. But everyone has their own preference.

There was one small modification to make (isn't there always?). The left and right earpieces were wired in parallel, which gave a very harsh law on the volume control. Connecting them in series improved the responsiveness greatly. The earpieces each have an impedance of 30 ohms, and the volume control is a 500 ohm pot.

Installation

The circuit is provided with a high impedance input, so that it is able to pick up a signal from the volume control of the television set. In the event I discovered that the set in question used a voltage controlled sound IC, so there is no signal on the volume control. The loudspeaker terminals provided a very acceptable signal instead, and the loudspeaker was muted with a switch.

Whatever signal takeoff you use, the procedure is to adjust the signal into the isolator box so that it is just below the clipping level. After this initial adjustment is made, the volume may always be adjusted on the headphones' volume control. For most signal takeoff points this initial adjustment may be made with the volume control on the set, but if that is not practical a preset can easily be added to the isolator board. **ETI**

TECH TIPS

Data Encryption Using Seeded Random Numbers

Rex Palmer,
Walton-on-Thames,
Surrey.

This programme (which I have called DEnS or Data Encryption non Standard) is a modified version of the program used in the article 'Practical Data Encryption' in the April 1986 issue of ETI. It runs on the BBC microcomputer and uses the 'seeded' random number facility so that both the sender and receiver of a message can generate the same set of random numbers.

In the program the 'key block' and 'initial block' are combined to provide the 'seed' and the 'initial block' is used to set the range of the random numbers that give the shifts for the cypher. These blocks are both loaded from data statements as in the original program but they are now only five sets long. Each set contains a number which should be between 0 and 99. Alternatively the 'key' and 'initial block' could be numbers in the range 1-2147483647 and the maths in lines 200-250 could be simplified.

You will also have noticed that Mode 6 is selected (line 20). This is because the values in lines 570-620 & 680-750 have been modified to allow the use of all the printable characters on the BBC microcomputer including 'space'. Mode 6 is used so that the printed characters match those marked on the keys.

(See also the letters on DES in Read/Write — Ed.)

```
100 REM ***DEnS PROGRAM***
110 REM by Rex Palmer, Mar 86.
120 MODE 6
130 REM ***KEY BLOCK***
140 S=0
150 FOR I=1 TO 5
160     READ Key
170     S=S*100+Key
180 NEXT
190 REM ***INITIAL BLOCK***
200 R=0
210 FOR I=1 TO 5
220     READ Int
230     R=R*100+Int
240 NEXT
250 :
260 :
300 K%=2147483647:M%=2000000000
310 S=S+R
320 IF S>K% REPEAT S=S-M%:UNTIL S<=K%
330 S=RND(-S)
340 IF R>K% REPEAT R=R-M%:UNTIL R<=K%
350 R=R MOD 256 +8
360 :
370 :
400 REM ***MAIN PROGRAM***
500 INPUT"Input E to encrypt or D to decrypt"R$
510 IF R$="E" THEN 540
520 IF R$="D" THEN 650
530 CLS:PRINT "Mistake":GOTO 500
540 REM ***ENCRYPTION***
550 PRINT "Plaintext","Ciphertext"
560 P$=GET$
570 P=ASC(P$)-32
575 IF P<0 OR P>94 THEN 560
590 K=RND(R)
600 X=K MOD 95
610 C=(P+X) MOD 95
620 C$=CHR$(C+32)
630 PRINT P$,C$
640 GOTO 560
650 REM ***DECRYPTION***
660 PRINT "Ciphertext","Plaintext"
670 P$=GET$
680 P=ASC(P$)-32
685 IF P<0 OR P>94 THEN 670
700 K=RND(R)
710 X=K MOD 95
720 C=P-X
730 IF C<0 THEN C=C+95
750 C$=CHR$(C+32)
760 PRINT P$,C$
770 GOTO 670
775 REM ***KEY BLOCK DATA***
780 DATA 71,2,49,85,26
785 REM ***INIT BLOCK DATA***
790 DATA 11,22,33,44,55
```

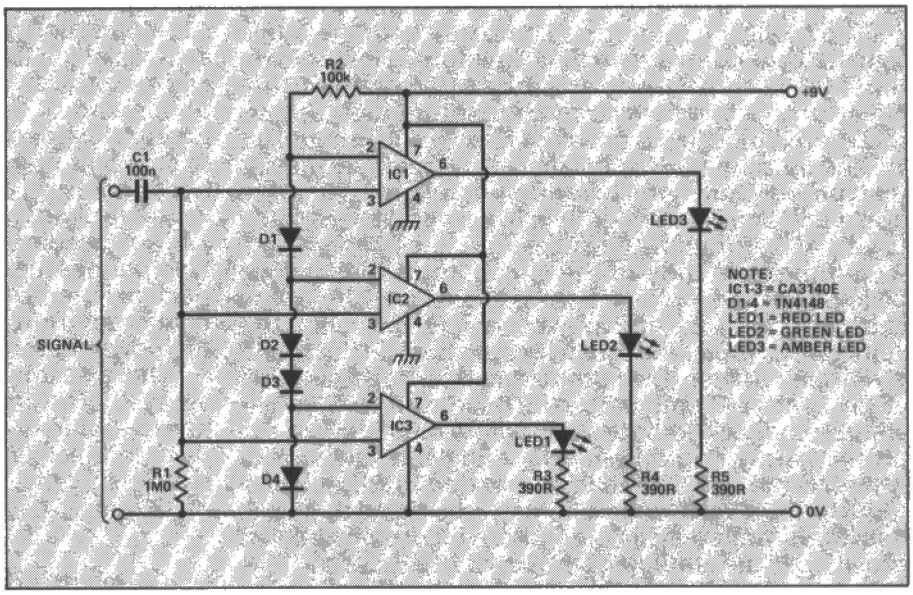
Easier Loading For Spectrums

Charles Rowbotham
Arnside
Cumbria

Cassette Tape is an inexpensive storage medium for microcomputer programs but many users finding difficulty in LOADing. This is usually because of noise or incorrect signal level.

This circuit is a peak voltage detector which uses three CA3140E op-amps wired up as differential amplifiers, with the inverting inputs held at a fixed positive voltage and the tape signal fed to the non-inverting inputs. An LED is connected to each output via a 390R resistor to earth. The 3140 has a slew rate of 13 volts per microsecond, so immediately the voltage on pin 3 exceeds that on pin 2, the amplifier swings into saturation and the corresponding LED lights — and vice versa.

The voltages on the inverting inputs of IC1, IC2 and IC3 are held at 2.0, 1.5 and 0.5 volts respectively by the chain of 1N4148 diodes connected to V+ via the 100k resistor, each diode dropping 0.5 volts. The CA 3140 behaves as a half-wave rectifier, when the voltage exceeds 0.5 volts the red LED lights, when it exceeds 1.5 volts the green LED lights and above 2 volts the yellow LED lights. The 1MO input impedance is high enough to have no effect on the signal.



The Sinclair power supply is used to provide the current and a positive connection only is needed, the 0 volts connection is made via the braid on the Ear socket cable.

In use the signal level is adjusted so that the yellow (amber) LED just glows when LOADing a program; the red and green LEDs should then be brightly lit and flicker in unison. If the green LED flickers erratically or extinguishes momentarily, the tape is badly modulated. Should the yellow LED flash brightly, signals at too high a level are being fed in, and should the red LED flicker or flash on a silent part of the tape, noise is present which may affect LOADing.

The unit is equally suited to the ZX81 with only a slight modification. The ZX81 optimum signal level is 2 volts peak, so just add another diode to the chain between IC2 and IC3.

SERVICE SHEET

Enquiries

We receive a very large number of enquiries. Would prospective enquirers please note the following points:

- We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications;
- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);
- Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We *may* make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;
- We receive a large number of letters asking if we have published projects for particular items of equipment. Whilst some of these can be answered simply and quickly, others would seem to demand the compiling of a long and detailed list of past projects. To help both you and us, we have made a full index of past ETI projects and features available (see under Backnumbers, below) and we trust that, wherever possible, readers will refer to this before getting in touch with us.
- **We will not reply to queries that are not accompanied by a stamped addressed envelope** (or international reply coupon). **We are not able to answer queries over the telephone.** We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.
- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

Backnumbers

Backnumbers of ETI are held for one year only from the date of issue. The cost of each is the current cover price of ETI plus 50p, and orders should be sent to: ETI Backnumbers Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire HP1 1BB. Cheques, postal orders, etc should be made payable to ASP Ltd. We suggest that you telephone first to make sure there are still stocks of the issue you require: the number is (0442) 48432. Please allow 28 days for delivery.

We would normally expect to have ample stocks of each of the last twelve issues, but obviously, we cannot guarantee this. Where a backnumber proves to be unavailable, or where the issue you require appeared more than a year ago, photocopies of individual articles can be ordered instead. These cost £1.50 (UK or overseas surface mail), irrespective of article length, but note that where an article appeared in several parts each part will be charged as one article. Your request should state clearly the title of the article you require and the month and year in which it appeared. Where an article appeared in several parts you should list these individually. An index listing projects only from 1972 to September 1984 was published in the October 1984 issue and can be ordered in the same way as any other photocopy. If you are interested in features as well as projects you will have to order an index covering the period you require only. A full index for the period from 1972 to March 1977 was published in the April 1977 issue, an index for April 1977 through to the end of 1978 was published in the December 1978 issue, the index for 1979 was published in January 1980, the 1980/81 index in January 1982, the 1982 index in December 1982, the 1983 index in January 1984, the 1984 index in January 1985 and the 1985 index in December 1985. Photocopies should be ordered from: ETI Photocopies, Argus Specialist Publications Ltd, 1 Golden Square, London W1R 3AB. Cheques, postal orders, etc should be made payable to ASP Ltd.

Write For ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

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So far as we know, all our advertisers work hard to provide a good service to our readers. However, problems can occur, and in this event you should:

1. Write to the supplier, stating your complaint and asking for a reply. Quote any reference number you may have (in the case of unsatisfactory or incomplete fulfilment of an order) and give full details of the order you sent and when you sent it.
2. Keep a copy of all correspondence.
3. Check your bank statement to see if the cheque you sent has been cashed.
4. If you don't receive a satisfactory reply from the supplier within, say, two weeks, write again, sending your letter recorded delivery, or telephone, and ask what they are doing about your complaint.

If you exhaust the above procedure and still do not obtain a satisfactory response from the supplier, then please drop us a line. We are not able to help directly, because basically the dispute is between you and the supplier, but a letter from us can sometimes help to get the matter sorted out. But please, don't write to us until you have taken all reasonable steps yourself to sort out the problem.

We are a member of the mail order protection scheme, and this means that, subject to certain conditions, if a supplier goes bankrupt or into liquidation between cashing your cheque and supplying the goods for which you have paid, then it may be possible for you to obtain compensation. From time to time, we publish details of the scheme near our classified ads, and you should look there for further details.

OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

Low Cost Audio Mixer (June 1985)

In Fig. 6 on page 39, the PCB foil pattern has been incorrectly shown as though from the copper side. The board is shown correctly from the copper side in the foil pattern pages. In Fig. 10 on page 40, the positive power rail at lower left should be shown connected to pin 8 of the TL072s, IC1-5). ⓧ

Noise About Noise (July 1985)

In Fig. 5 on page 24, no connection should be shown between the cathode of the diode and the negative side of the 470u capacitor. ⓧ

Printer Buffer (July 1985)

The case specified is actually larger than the one used for the prototype. It will, of course, work perfectly well, but if you want to a compact unit use a Verocase 202-21038H (180 x 120 x 65mm) rather than a Verocase 202-21035. The regulator IC17 should be bolted to the back of the case to provide heatsinking or, alternatively, fitted with a TO220 heatsink.

Please note that the designer, Nick Sawyer, has been in touch to inform us that the refresh problem we mentioned in September ETI is dealt with in the printer buffer software. In this case there is no need to replace the TMS 4416 dynamic RAMs, although as far as we know the replacement parts mentioned (Hitachi HM48416 DRAMs) will cause no problems. The full text of Nick Sawyer's letter will appear next month. Meanwhile, our apologies for any confusion caused.

Cortex Parallel I/O (September 1985)

Pins 1 and 2 of IC2 have been swopped over on both the circuit diagram (Fig. 1) and the Veroboard overlay (Fig. 2). Pin 1 should connect to pin 16 on the header and pin 2 should connect to pin 2 on the header.

Intel 8294 Data Encryption Unit (September 1985)

It should be apparent from the text, page 35, that an actual program has been omitted. This program is for use with the SDK 8085 kit only, and copies may be obtained from us on receipt of a stamped addressed envelope.

Tech Tips — Novel Input Stage (October 1985)

The caption against the lower figure should read "Low noise output at *minimum* gain", not maximum gain. ⓧ

Chorus Unit (November 1985)

IC3 is shown on the circuit diagram on page 49 connected to the 9V supply. It should be connected to the 5V supply. The foil pattern connections to this IC are correct. ⓧ

Foil Patterns (November 1985)

The foil patterns for the Modular Test Equipment Waveform Generator and the Chorus Unit are shown from the component side rather than the copper side.

The Rhyth-ROM (November 1985)

R2 has been omitted from the parts list on page 35. It's value is 39k, as given on the circuit diagram. Also in the parts list, R821 should, of course, read R8-21.

Cymbal Synth (November 1985)

R18 is labelled as R20 on the circuit diagram (page 59) and the real R20 is missing altogether. It should be shown connected between the base of Q3 and the +ve rail. The overlay diagram is correct in both cases. (KX)

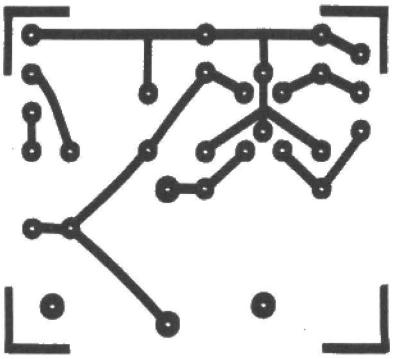
Digibaro (February 1986)

Capacitors C1, C3, C5 and C7 should be 470u 25V types as shown on the circuit diagram, not 47u 25V types as stated in the parts list. We have also been told that one of the companies mentioned in Buylines, Hawke Electronics, no longer supply the MPX100a pressure transducer. The other company recommended, Macro Marketing, should still be able to help.

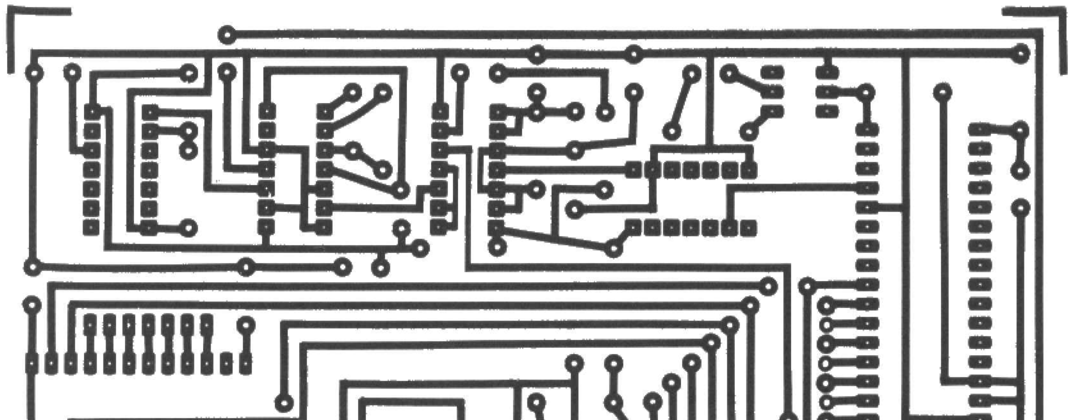
(KX) = ~~FROM~~ TO ETI NOV 1995 P.58 ADDED

ⓧ = SAME AS ETI ~~FEB~~ & MAR 1986 ALL READY ADDED

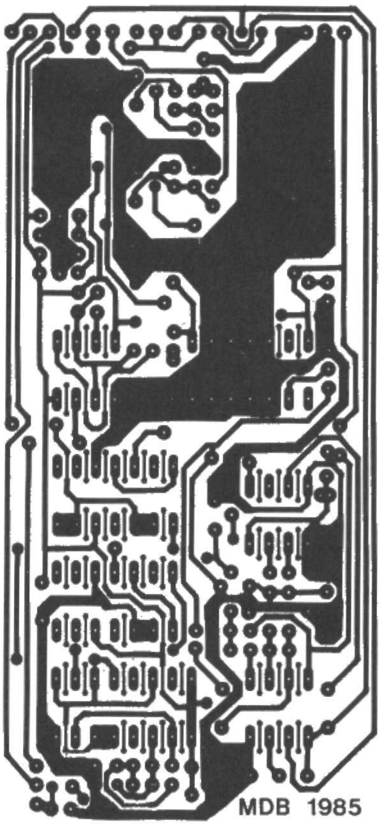
PCB FOIL PATTERNS



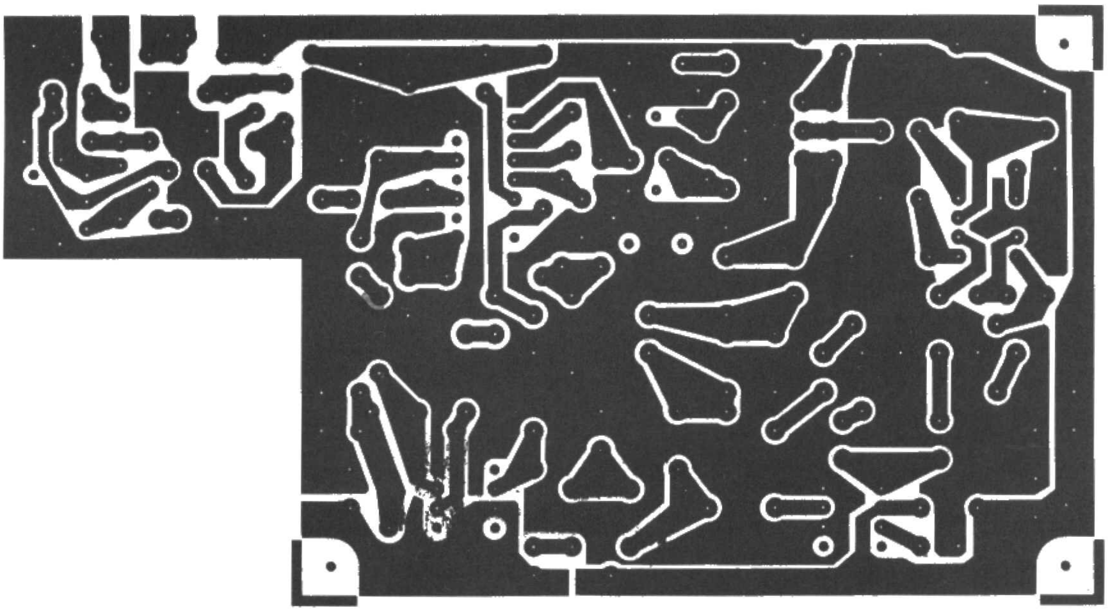
The MIDI to CV converter PSU board.



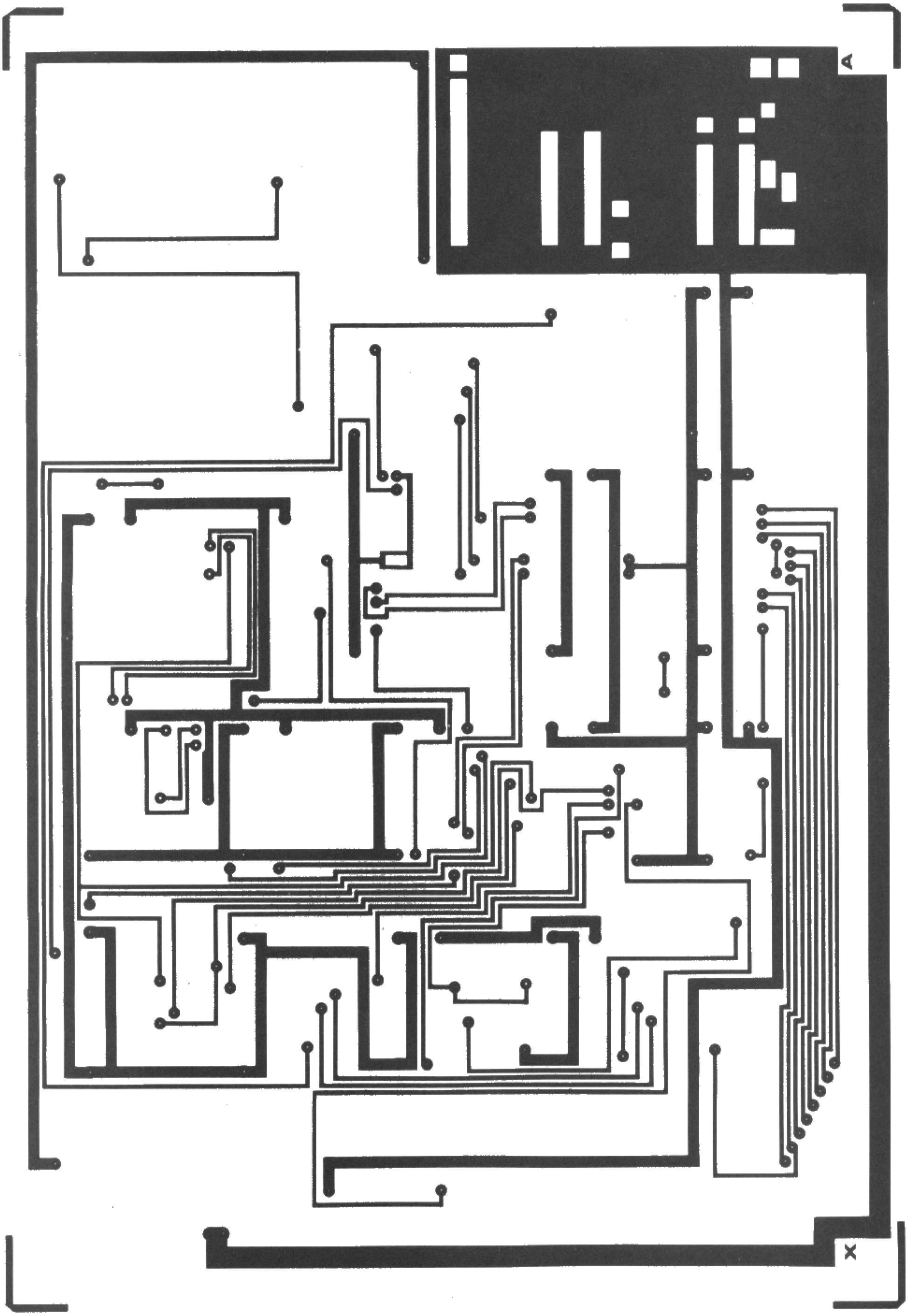
The main board of the MIDI to CV converter.



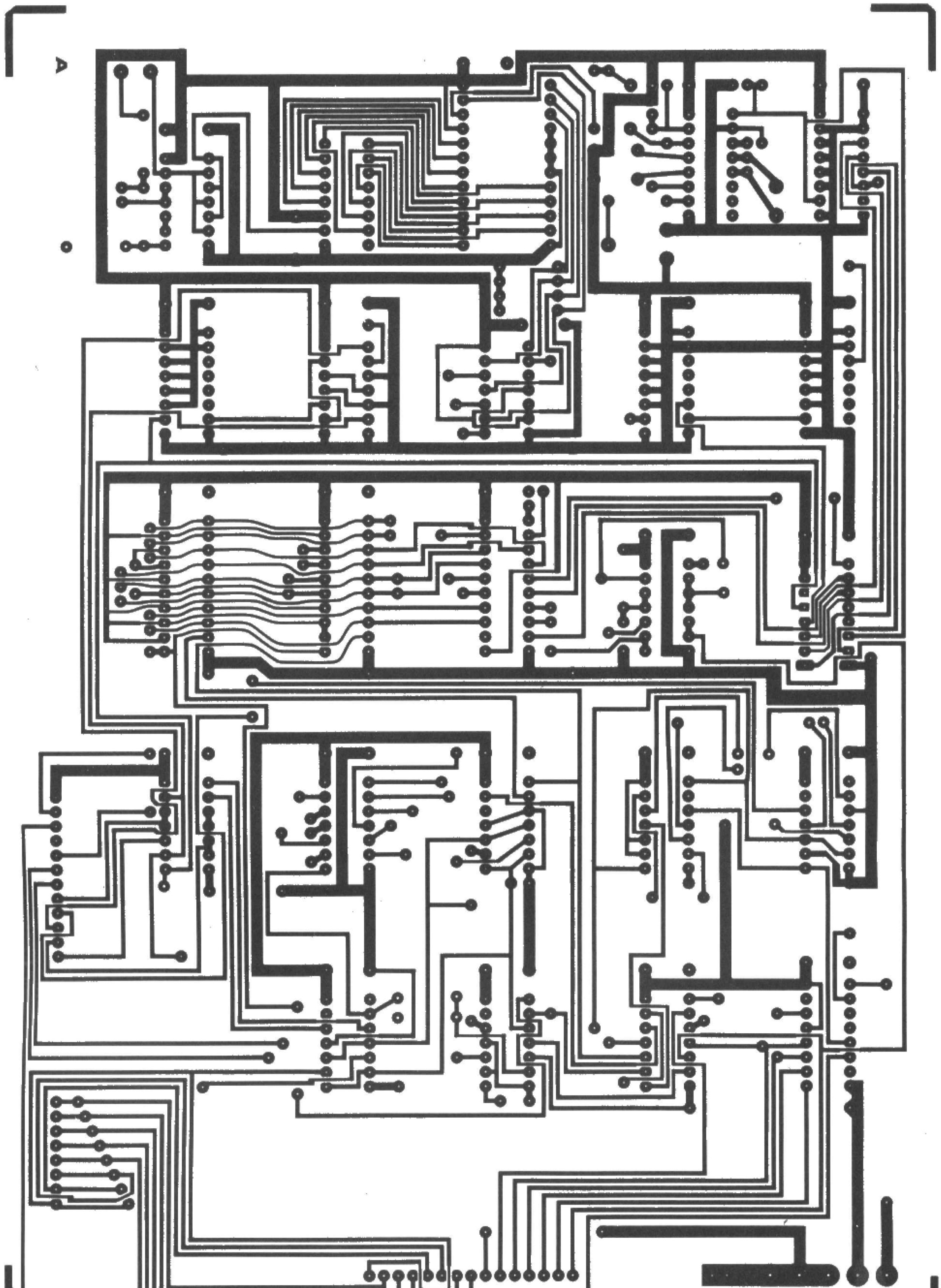
The foil pattern for the troglograph board.



The foil pattern for the 80m receiver board.



The top and bottom foils for the digital sound sampler board.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PLAYBACK

The idea of digitising sound is not new, but until the advent of the compact disc there was no practical medium for bringing digitised audio into the living room (unless you happen to be Phil Collins).

The compact disc stores information in the form of small pits on a reflective surface, which can be read by a laser beam. The pits which the laser scans are not particularly large and a full length recording appears to need something like 600 megabytes, at one bit per pit, not including the parity bits. The disc itself is 4.75in in diameter.

Given this density of data, very accurate and stable servo control of the laser aiming and focussing is needed. As the disc rotates, slight warping can require the laser to refocus widely and continually. Similarly, an eccentricity too small to be noticed by the naked eye can amount to tens of tracks in width, so that the laser, in its own terms, must swing wildly around. On this microscopic scale, warping and eccentricity are impossible to eliminate. On top of all this, in a portable machine the servo must cope with the shake, rattle and roll of everyday travel.

Error Correction

The discs are produced by pressing. Though this is done in a clean room, there will inevitably be imperfections. The serial data is coded in such a way as to allow the read errors to be corrected.

The error correction system is quite complex but it is possible to give a simplified description. The first level of correction is based on the use of parity bits, in such a way that up to two bits in error out of any one data word can be corrected. In addition to this, if you visualise the data arranged in frames with successive words on successive lines, then the same error corection can be applied when the data is read in a vertical direction as in a horizontal direction.

If all this fails to correct corrupted data, the player mutes its output until valid data is present. For this reason, any error on the disc of sufficient size to affect the sound at all will cause a noticeable silent spot. I have already had to return one CD because it had a minute bubble moulded into it, causing half a second's silence in the middle of a track — very noticeable.

Conversion

Once valid digital data is available, it must be converted to an analogue signal before it is of any use. It is at this point that the quality of the disc player has most effect on the sound quality. The reasons for this are quite complicated.

The most obvious factor affecting sound quality is the number of bits the DAC (digital to analogue converter) has. The more bits, the smaller the steps into which the continuous analogue waveform is broken, and therefore the more accurate the reproduction. This, of course, only applies if the bits actually mean something. To be meaningful, 16-bit conversion can only tolerate a DAC step size error a quarter of the size acceptable for 14-bit conversion.

The most important characteristic of the DAC is that it should be monotonic — that is to say that every increase in the binary number should produce an increase in the analogue output voltage. This is a tall order for a 16-bit DAC. In order to maintain credibility when changing from 0111111111111111 to 1000000000000000 the step size of the most significant bit must be accurate to about .0015%. Now where did I put the 0.001% resistors?

DAC errors, particularly monotonicity errors, cause both harmonic distortion and, perhaps more important at these rarified heights of quality, intermodulation.

Out of the DAC comes a waveform containing, in addition to the wanted audio, a signal at the sampling frequency (41.2kHz). Bearing in mind that the aim is to provide an audio response to 20kHz, a very sharp audio filter is required to attenuate the unwanted ultrasonic signal, leaving the wanted audio unaffected.

Oversampling

Some CD player manufacturers, notably Philips, get round the need for a 'brickwall' audio filter by using each sample four times, and implementing a digital filtering algorithm to tailor the response outside the audio range. This leaves the in-band performance virtually perfect. The ultrasonic signal to be removed is now at a high enough frequency to allow a filter to remove it without repercussions in the audio range. This technique virtually forces the use of a separate DAC for each channel, because of the speed of conversion required.

On the other hand, using a brickwall filter, as Sony does, allows the same DAC to be multiplexed between the left and right channels. This reduces power consumption, which is important in a portable CD player. A possible problem with multiplexing the DAC is that the left and right channel signals are presented at different times. This should not affect the stereo image, but could cause trouble if the amplifier were to be used switched to mono. There are rumours that this problem came to light when the BBC first tried to use CD on air.

System Performance

Having mentioned some of the pitfalls and problems of CD technology, in my opinion most current CD players are so good that the listener will not notice any defect in the sound due to the CD player, even on the best programme material. Measurable defects just about become significant when the rest of the hi-fi system is beyond reproach, and is installed in a cellar lined with acoustic tiles! Listening on very good headphones also tends to emphasise any shortcomings. Compact disc is streets ahead of any other non-professional medium for perfect reproduction.

Andrew Armstrong

OPEN CHANNEL

With cellular radio services in the UK only a couple of years' old, there are already signs that the systems aren't all they are cracked up to be. Recent operational price rises alongside equipment price cuts suggest that operators are having to re-define their tactics as to how they market their wares.

Any existing services also have a limited operational span. A digital cellular radio system is planned for the 1990s, which is to follow a European standard, currently under negotiation. At present a number of companies (none of them British!) have built demonstration systems and the standard is soon to be announced.

I can't help the feeling that the many thousands of existing cellular radio users are going to be badly let down by the existence of this second wave of cellular technology.

Exchange Change

It appears that Mercury, the telephone rival to BT, is to launch a new service (new to this country, at least) which will effectively eliminate the need for customers to have on their premises a prvate automatic branch exchange (PABX). Typically, PABXs are used by customers with a large number of 'phone extensions to route incoming calls to the right extension and allow outgoing calls to be made from extensions. Internal calls between 'phone extensions on the PABX are made without access to the telephone network and are thus free. There are a few problems, however. First, PABXs for large organisations are complex, bulky (depending on the technology used), and costly. Also, once a customer has purchased a PABX he is stuck with its facilities and features, unless a complicated change is made (again, costly and what's more, time-consuming).

Mercury is to make use of a system which has been available in North America for a while now, known as virtual private network services or centrex (a shortened form of 'central exchange'). The service works by allocating part of a digital local exchange to a particular customer. No other telephone users can gain access to that part of the exchange, except via the customer's switchboard. So, in practice, the subsectioned part of the exchange acts just like a PABX except that it is not on the customer's premises. The customer merely rents the centrex service and is saved the problems of purchasing, servicing and housing a PABX. What facilities and functions the centrex service allows the customer are determined purely by software (it's a digital local exchange, remember) so changes in the number of 'phone extensions, operating features etc, are a simple matter of changing a program or two — cheaply and quickly.

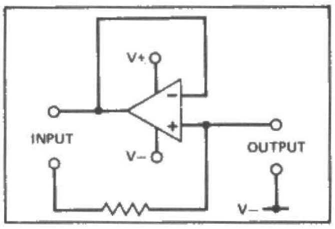
To say that virtual private network services herald the end of true PABX services is probably a bit of an overstatement, but Mercury's move must surely be sending a few jitters around PABX manufacturers' boardrooms at the moment. At a time when so many manufacturers are investing a great deal of money in this area, producing new yet relatively uninteresting PABXs, Mercury has simply looked at what is already in operation elsewhere in the world and seen a market need here. Virtual private network services are a true rival to PABX services and stand a good chance of wiping them out altogether.

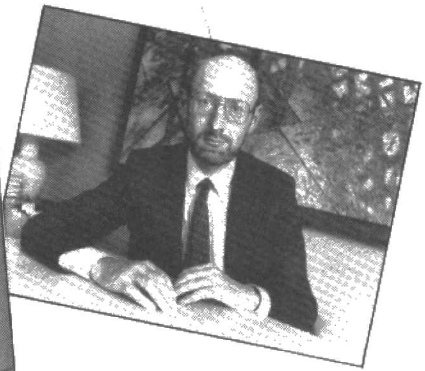
Keith Brindley

ALF'S PUZZLE

Alf considers himself quite an expert on op-amps, having worked his way through every single project in '101 Exciting Things to do With a 741 on a Rainy Afternoon.' One definite conclusion he has reached is that the input to an op-amp always goes to the flat side with + and − on it, and the output always comes from the pointy bit. You can imagine his surprise when he came across the circuit in Fig. 1 the other day. The input is a floating voltage source connected to the output of the op-amp. The output comes from the non-inverting input. Is it a mistake? Can you really use op-amps back to front? What does the circuit do?

The answer to last month's puzzle. The circuit is an astable multivibrator drawn in an unusual way. Somehow, I don't think that Alf invented it.





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SCRATCHPAD

by Flea-Byte

The big story of the moment — at least, it's the big story as I write — is Amstrad's takeover of Sinclair. These columns have, in the past, had little sympathy for the over-inflated claims made by and on behalf of Clive Sinclair. All the same, it is not without a tinge of sadness that we note the latest instalment in the never-ending story of Sinclair's rise and fall — and rise and fall and rise and fall and rise and fall and rise and fall ....

Pure Genius

The one thing that can be said in Sinclair's favour — unquivocally, I mean — is that he offers the opportunity for amusing and entertaining copy. At times, he offers little else. All of you will recall his championing of the electrified trike at a time when the scoffers scoffed and the doubting Deborahs said that the trike was a ridiculous fad that would barely get off the ground, much less on to the road. Many of you will remember how Sinclair had the vision to manufacture a TV with an unwatchable screen at a time when so-called pundits were all saying that nobody would want to watch an unwatchable television — especially one in black and white.

The list of Sinclair's witty and essentially practical ripostes to the nervous Noras of the world is lengthy indeed. Whenever they said that something couldn't be done, Sinclair was there to produce something that didn't do it. For this he was acclaimed by many media-people as the greatest British scientist of his age. How long, one wonders, will it take for these people to hand that particular crown over to Alan Sugar — the man behind Amstrad.

A Spoonful Of Sugar ...

I have already noticed that Sugar's credentials seem to be getting a subtle boost. Recently, I've been assured that Sugar used to be a hobbyist — probably used to read ETI, that sort of thing. Of course, Sinclair used to write for constructors. Now, I don't know whether this is true about Sugar or not, but until recently it was always said that Sugar's introduction to the electronics business was through starting up a little enterprise replacing damaged car aerials in a part of London where car aerials tended to be damaged quite a lot. But perhaps he's simply being prepared for his Nobel prize (or knighthood?).

One thing that does distinguish Sugar from Sinclair (which is sometimes difficult to do since both of them need a shave) is their marketing approach. I have to confess to being someone who has, in his time, owned both Sinclair and Amstrad products. The Amstrad product I once owned was a stereo amplifier, about which I had no complaints.

I remember that the output stage went once, but the amp was 'modular' and so I took out the module and sent it to Amstrad who sold me a cheap replacement part. The only problem was that the fault kept re-occurring (and not just in my amp, either). But, as I've said, I had no complaints since the unit was cheap to buy and cheap to fix and performed reasonably well. At the time, I wanted no more from my sound system.

It's been said, with justice I think, that Sugar's trick is to make cheap items look expensive. The buyer is impressed, thiinking that he or she is getting all those facilities and all that sheen and surface finish for so little. The PCW8256 word processor, which has really made Sugar's name, looks like a computer costing twice or three times as much. In some ways, it performs like a computer costing twice or three times as much and — it must be said — it is deservedly popular among individual and small business users. But it is not the *same* as a computer costing twice or three times as much, any more than an Amstrad audio system is the same, as, say, even a Trio or a Technics system.

The fact is that Sugar is a salesman with something of the disreputable air of a market trader. He will offer you, the punter, an irresistible bargain at a ridiculously low price and then he'll cap it by throwing in a free gift or cutting the price in half. But, as they say in the Office of Fair Trading, 'caveat emptor', buyer beware. Nobody becomes 'a self-made multi-millionaire' (a newspaper description of Sugar) by giving things away.

. . . And The Spice Of Life

Perhaps the electronics business *needs* marketing nous like Sugar's. It is certainly something Sinclair could have done with.

Even if he misses the target more often than he hits it, Sinclair is an innovator. You won't catch Sugar trying to flog you a computer with a 68000-family chip in it — not today and certainly not two or three years ago. No, the good old Z80 is good enough for Amstrad machines, because it's tried and tested and, above all I'd say, because it's cheap. Sinclair goes out on a limb more times than he probably cares to remember. Often, it should be apparent to most people that the limb is very, very thin and breakable — but not to Clive. Sugar, on the other hand, only trusts the sturdiest sorts of branch — as befits a man much bulkier than Sinclair.

The Show Goes On

There is something of Laurel and Hardy about the pair. It's difficult to know who — Stan or Ollie — deserves the most sympathy — one, the artless fool, the other a scheming buffoon. Of course, Sinclair and Sugar are both, in their ways, enormously successful men and this alone sets them well apart from Stan and Ollie. All the same, I can't help but wonder what further amusements they may have up their sleeves for us.

Sugar, I'm told, intends to launch an IBM compatible PC on the market — and certainly he has recently been at pains to point out that he was always more interested in the business computer market than the very first Amstrad machine — the CPC464 — would suggest. Personally, I think he'll lose money on an IBM compatible, but the move would be appropriate to a man who probably sees himself as something of a giant-killer.

Sinclair, on the other hand, seems to have lost all interest in computers. The latest version of Sinclair Research will be a holding company looking after Clive's other interests — a cordless telephone being developed in Winchester as the first of a series of telecommunications products, a group undertaking research for large corporations (the so-called 'MetaLab') and the completion of the much-vaunted wafer-scale integration project. Of these, only the third — wafer-scale integration — fits the Sinclair profile as an exciting and probably doomed adventure. Barclays Bank are backing the WSI project, but they may not have heard of Gene Amdahl and Trilogy. One source close to Sinclair has said that WSI 'is either dramatically right, or totally wrong'. With the backing of half-a-dozen major computer companies in Europe, Amdahl found that WSI was unworkable. Sinclair may know better, but somehow I doubt it.

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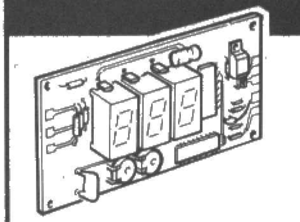

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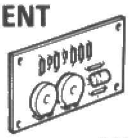

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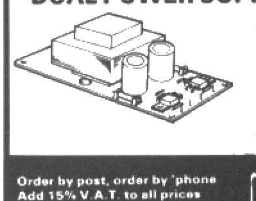

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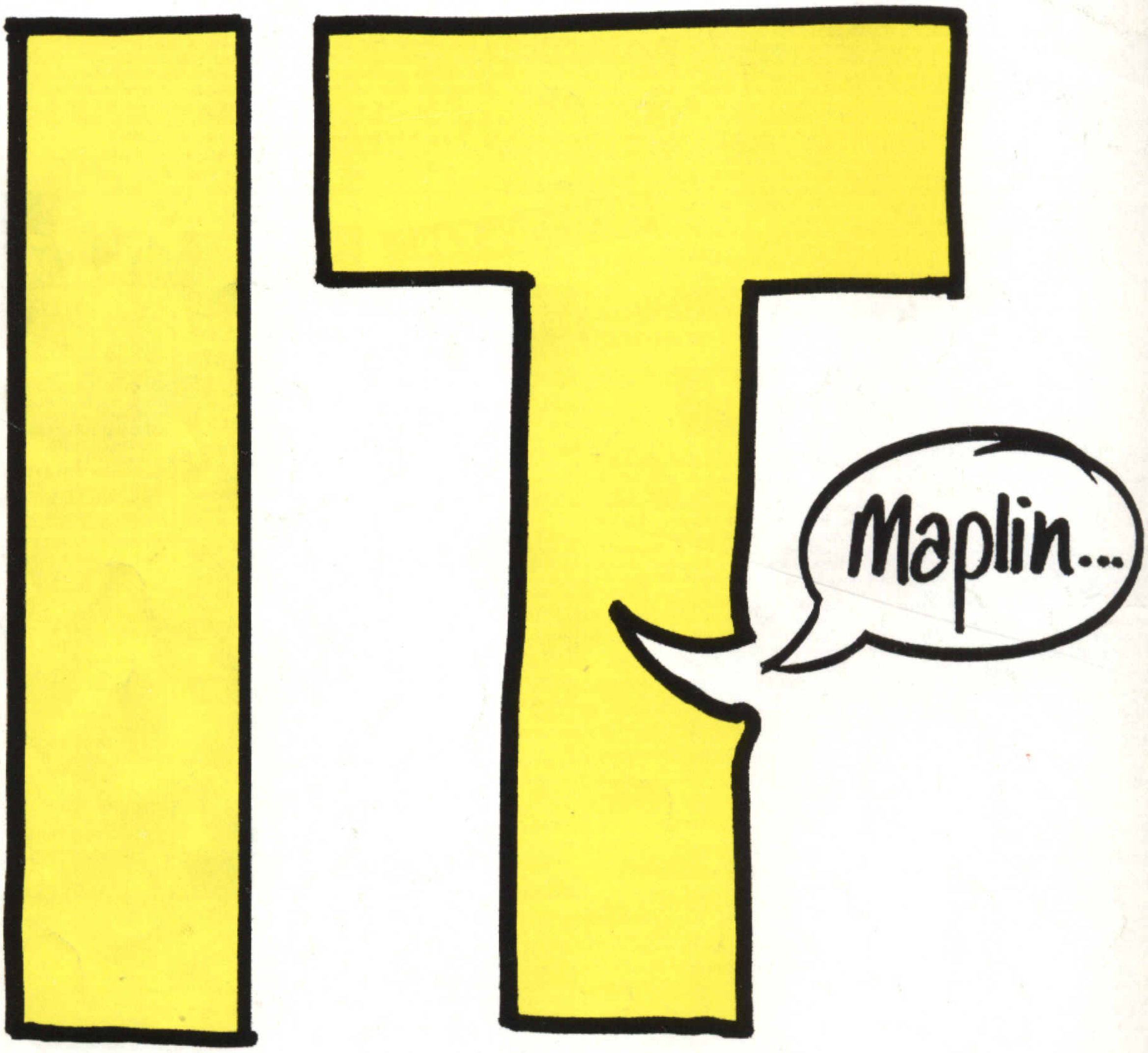

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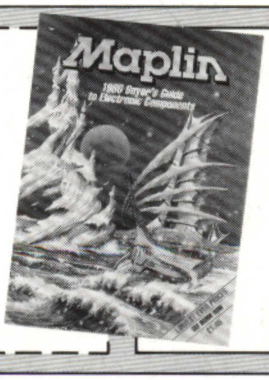

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